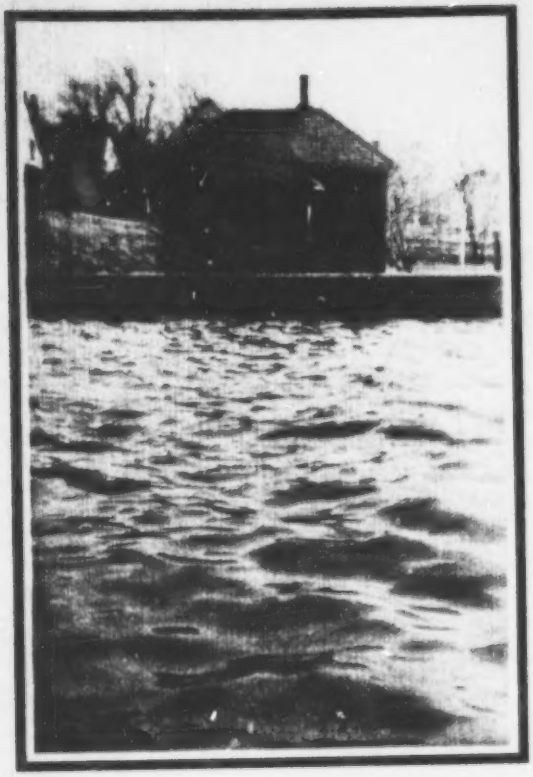
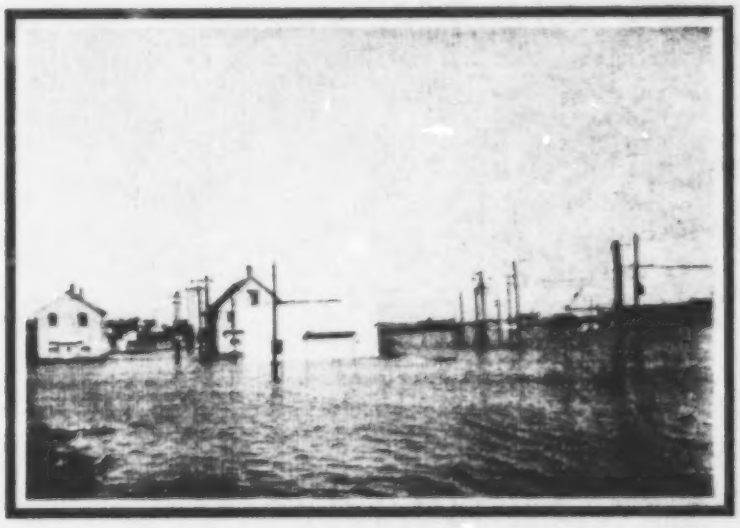


FINAL REPORT

DOCUMENTATION AND ASSESSMENT OF FLOODING IN THE TOWN OF SACKVILLE AND ENVIRONS



Prepared for: THE FLOOD RISK MAPPING TECHNICAL COMMITTEE
CANADA-NEW BRUNSWICK FLOOD DAMAGE REDUCTION PROGRAM

Prepared by: WMS ASSOCIATES LTD.

WMS 3028
MARCH 1990

90-06501/

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OBJECTIVES

The objective of this study is to investigate the nature, history and extent of flooding in the Town of Sackville and the surrounding area including the Tantramar River and Frosty Hollow Brook. The area has a history of flooding which is documented back to 1759 when the first settlers arrived and began to build dykes to protect the low-lying marshlands.

The study reviews the hydrotechnical aspects of the area to evaluate some of the causes of the flooding. Flooding is caused by high tides, heavy rainfall, snowmelt or a combination of these factors. The land is protected by an extensive network of man-made dykes which are equipped with aboiteau (uni-directional pipes equipped with flap gates) to allow river flow and runoff to reach the sea during low tides. A tidal control dam is located at the mouth of the Tantramar River and serves to prevent the high water levels in Cumberland Basin from travelling up the river and flooding land near the river bank.

STUDY AREA

The study area is comprised of the Town of Sackville and surrounding communities, including Middle Sackville and Frosty Hollow. The study area also includes the flood plains of the Tantramar River and Carters Brook (Figure 1.1).

The Town of Sackville is located in southeastern New Brunswick approximately 10 kilometres (km) from the New Brunswick-Nova Scotia border. The Town is bordered on the east by the Tantramar River which runs into the Cumberland Basin which is an arm of the Bay of Fundy. Frosty Hollow Lake and Brook are located to the southeast. The land in Sackville slopes gently towards the river and generally is low and poorly drained.

Sackville is a university town which serves as a service and employment centre for the surrounding district (Figure 1.1). There is a centralized business district and residential development in the town core extending as ribbon type development into nearby areas.

METHODOLOGY AND SCOPE OF WORK

An initial investigation was conducted of previous reports, photographs, newspapers and historical archives. This investigation provided the dates and brief descriptions of major flood events in the study area. The physical effects and extent of flooding were determined through subsequent field investigations, where possible.

Local residents and officials who have knowledge of past floods were interviewed. A questionnaire (Appendix A) was developed to guide the interviewer, ensuring that interviews were conducted consistently. The objective of the interviews was to identify known flood limits from past events and to obtain available photographic or other evidence of these.

A ranking system developed for previous historic flood studies (WMS 1989; Snyder 1989) was used to evaluate the reliability of flood levels and points identified. The objective of the evaluation of the flood points was to ensure that the points identified for surveying would provide good spatial coverage of the study area with a sampling from as many known flood events as possible.

The points obtained were plotted on longitudinal profiles of the study area to allow comparison of the elevations obtained for specific flood events. Separate profiles representing the Town of Sackville and Carters Brook were used in the plotting to provide a method of comparison of the elevations obtained in the field survey. The elevations were also plotted on mapping of the area which was then used to obtain an envelope of maximum flooding for the study.

The open water flow for a 1 in 100 year return period event was estimated for the Tantramar River at the railway bridge below the Tantramar Dam using regional flood frequency methods (DMAE and IWD 1987). Data was collected on aboiteau and storm drainage systems within the study area. Information on antecedent weather and flow conditions were also collected and summarized for antecedent conditions at the time of flooding events to allow an evaluation of the causative factors of flooding in the area.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the flood of 1962 is the highest on record. There were also two other significant floods in the area, in 1869 and in 1989. The flood of 1869 may have produced higher water levels than the 1962 flood but there was insufficient data to determine the extent and depth of flooding. The flood in 1989 was localized in the Town of Sackville, and did not result in flooding in other parts of the study area.

There have been a number of changes to the study area over the years which have had an influence on flooding. A tidal control dam on the Tantramar River was completed in 1960 which now controls the flow on that river and has proven effective in preventing widespread flooding of the Tantramar Marshes. In 1965 an additional outlet was added to Aboiteau NB37-10 on Carters Brook. This aboiteau now has an increased capacity and would be more effective in passing the runoff from a flood of the magnitude of the 1962 flood.

The capacity of Aboiteau NB37-10 should be reviewed to ensure that it has the capacity to pass the estimated 1 in 100 year runoff without causing flooding of the Frosty Hollow area. A detailed survey of the existing structure is required to allow proper evaluation of the capacity.

All aboiteau in the study area must be maintained in good working order. Most of the aboiteau are now over 35 years old and are beginning to show signs of age. Reduced capacity due to jamming of flap gates or collapsed barrels could lead to flooding in the area.

If the capacity of Aboiteau NB37-10 is found to be insufficient to pass the 1 in 100 year runoff, the capacity of this aboiteau should be increased. Consideration should also be given to the construction of a cross-dyke between Sackville and Frosty Hollow. This would prevent water from Carters Brook from entering the Town of Sackville from this direction, as occurred during the 1962 flood.

The dykes which protect the area appear to be well maintained and of sufficient height to prevent overtopping under most combinations of wind and tide. These dykes are also showing signs of age, with some section experiencing damage due to winter storms and erosion from wave action. The costs of maintenance are increasing as more extensive

repairs are needed to the structures which are reaching the end of their functional life. It may be necessary to upgrade the dykes and other structures in the near future so that they will continue to be effective in preventing flooding of the study area.

It is recommended that the approaches to all aboiteau and storm drainage systems be kept free of debris. The functioning of the aboiteau can be impaired by the presence of debris, and clogging of the approach channels may delay water reaching the aboiteau so that it may be discharged during the low tide period.

There are not enough points to provide the exact extent of flooding in the study area. Water levels are reported generally as heights against structures and not as the maximum extent of inundation. Therefore the water levels selected to define the maximum limit of flooding are based on the assumption that the same maximum water level would apply to all of the study area.

This study found that the maximum historic level of flooding in the Town of Sackville and in Frosty Hollow are elevations 7.9 m and 8.0 m, respectively. It is recommended that these levels be used for the designation of flood risk areas. It must be remembered, however, that this level is dependent on dykes and aboiteau being maintained. Therefore, a return period cannot be assigned to this level of flooding. If the dykes protecting Sackville are breached, the flood level may reach or exceed the maximum historic level.

OBJECTIFS

Cette étude a pour but d'étudier la nature, l'histoire et l'étendue des inondations dans la ville de Sackville et dans les environs, y compris la rivière Tantramar et le ruisseau Frosty Hollow. Il existe pour la région étudiée, de la documentation sur les inondations qui remonte à 1759 lorsque les premiers colons sont arrivés et ont commencé à construire des digues pour protéger les terrains marécageux bas.

Un autre objectif de l'étude est d'analyser les aspects hydrotechniques de la région étudiée pour évaluer certaines causes des inondations. Les inondations dans la région sont provoquées par les marées hautes, les écoulements du printemps, la fonte des neiges ou une combinaison de ces facteurs. Le terrain est protégé par un vaste réseau de digues construites par l'homme qui sont munies d'aboiteaux (tuyaux unidirectionnels avec vannes à clapet oscillant) afin de permettre au débit et aux écoulements de la rivière d'atteindre la mer à marée basse. Un barrage de contrôle des marées se trouve à l'embouchure de la rivière Tantramar. Il sert à empêcher les hautes eaux dans le bassin de Cumberland de voyager en amont dans la rivière et d'inonder les terrains le long de la rivière.

RÉGION ÉTUDIÉE

La région étudiée comprend la ville de Sackville et les localités avoisinantes, y compris Middle Sackville et Frosty Hollow. Elle englobe aussi les zones inondables de la rivière Tantramar et du ruisseau Carters (figure 1.1).

La ville de Sackville est située dans le sud-est du Nouveau-Brunswick à environ 10 kilomètres (km) de la frontière du Nouveau-Brunsdwick et de la Nouvelle-Écosse. Elle est délimitée à l'est par la rivière Tantramar se déversant dans le bassin de Cumberland qui est un bras de la baie de Fundy. Le lac et le ruisseau Frosty Hollow se trouvent au sud-est. Le terrain à Sackville est légèrement incliné vers la rivière et généralement bas et mal drainé.

Sackville est une ville universitaire qui sert de centre de services et d'emploi pour le district immédiat (figure 1.1). Il s'y trouve un centre des affaires et une zone d'aménagement résidentiel au centre-ville qui s'étend en aménagement linéaire aux zones immédiates.

MÉTHODOLOGIE ET ÉTENDUE DES TRAVAUX

Une étude préliminaire a été effectuée à partir des rapports précédents, des photographies, des journaux et des archives historiques. Cette étude a permis d'identifier les dates et de fournir une courte description des inondations majeures survenues dans la région étudiée. Les effets physiques et l'étendue des inondations ont été déterminés par des études sur place, lorsque cela était possible.

On a interviewé des résidents et des représentants locaux qui possédaient des renseignements sur les inondations survenues par le passé. Un questionnaire (annexe A) a été préparé pour orienter l'intervieweur afin que les entrevues soient effectuées de façon constante. L'objectif des entrevues était d'identifier les repères de crue connus à partir des événements précédents et d'obtenir les preuves photographiques ou autres disponibles.

Un système de classement établi pour les études des inondations précédentes (WMS 1989; Snyder 1989) a été utilisé afin d'évaluer la fiabilité des repères de crue et des niveaux de crue identifiés. On voulait, pour les études ultérieures, avoir accès à un vaste échantillonnage qui comprendrait le plus grand nombre de points identifiés possible et qui couvrirait la plus grande partie possible de la région étudiée.

Les points obtenus ont été tracés sur des profils longitudinaux de la région étudiée afin de permettre la comparaison des élévations obtenues pour les inondations particulières. Des profils distincts représentant la ville de Sackville et le ruisseau Carters ont été utilisés pour le traçage afin d'obtenir une méthode pour comparer les élévations obtenues lors de l'étude sur place. Les élévations ont été aussi tracées sur des cartes topographiques utilisées ensuite afin d'obtenir une enveloppe maximale des niveaux de crue pour l'étude.

Le débit de l'eau libre pour la rivière Tantramar a été estimé au pont ferroviaire en bas du barrage Tantramar à l'aide de méthodes régionales de fréquence de crue (MAME et IWD 1987). On a obtenu des données sur les aboiteaux et les systèmes de drainage pluvial. On a aussi recueilli des données sur les conditions météorologiques et les débits antérieurs lors des inondations; ces données ont été résumées pour permettre une analyse des causes des inondations dans la région.

CONCLUSIONS ET RECOMMANDATIONS

La présente étude permet de conclure que l'inondation de 1962 est la plus haute qui a été enregistrée. Deux autres inondations importantes ont eu lieu dans la région, en 1869 et en 1989. L'inondation de 1869 a pu avoir donné des niveaux d'eau plus élevés que celle de 1962, mais les données étaient insuffisantes pour déterminer la portée et la profondeur de l'inondation. L'inondation de 1989 était localisée dans la ville de Sackville; elle n'a pas entraîné l'inondation des autres parties de la région étudiée.

Au cours des années, la région étudiée a subi un certain nombre de changements qui ont eu un effet sur l'inondation. Un barrage de contrôle des marées sur la rivière Tantramar a été achevé en 1960. Cet ouvrage contrôle maintenant le débit de cette rivière et s'est avéré efficace pour prévenir l'inondation générale des marais de Tantramar. En 1965, une autre sortie a été ajoutée à l'aboiteau NB37-10 sur le ruisseau Carters. Cet aboiteau a maintenu une capacité accrue et serait plus efficace pour les passages de l'écoulement d'une inondation de l'ampleur de celle de 1962.

La capacité de l'aboiteau NB37-10 devrait être examinée pour déterminer s'il a la capacité de passer l'écoulement estimé pour une fois dans 100 ans sans inonder la région de Frosty Hollow. Un examen détaillé de l'ouvrage actuel s'impose pour permettre une évaluation adéquate de la capacité.

Tout aboiteau dans la région étudiée doit être maintenu en bon état de fonctionnement. La plupart des aboiteaux sont maintenant âgés de plus de 35 ans et commencent à montrer des signes de détérioration. La capacité réduite en raison du coincement des vannes à clapet oscillant ou des barils effondrés pourrait provoquer l'inondation de la région.

Si la capacité de l'aboiteau NB37-10 est jugée insuffisante pour passer l'écoulement d'une fois en 100 ans, elle devrait être augmentée. Il faudrait aussi étudier la possibilité de construire une digue fautive entre Sackville et Frosty Hollow. Cela empêcherait l'eau du ruisseau Carters de pénétrer dans la ville de Sackville à partir de cette direction, comme lors de l'inondation de 1962.

Les digues qui protègent la région semblent être bien entretenues et d'une hauteur suffisante pour empêcher les débordements dans la plupart des conditions de vent et de marée. Ces

digues manifestent aussi des signes de détérioration, certaines sections étant endommagées en raison des tempêtes d'hiver et de l'érosion causée par les marées. Le coût d'entretien augmente à mesure que des réparations plus importantes s'avèrent nécessaires pour les ouvrages qui arrivent à la fin de leur vie fonctionnelle. Il pourrait falloir améliorer les digues et les autres ouvrages dans un avenir rapproché afin qu'ils puissent continuer d'être efficaces pour prévenir l'inondation de la région étudiée.

On recommande que les canaux d'amenée à tous les aboiteaux et aux systèmes de drainage pluvial soient libres de débris. Le fonctionnement de l'aboiteau peut être perturbé par la présence de débris, le blocage des canaux d'amenée peut retarder l'arrivée de l'eau à l'aboiteau de façon qu'elle puisse être évacuée à marée basse.

Il n'y a pas suffisamment de points pour fournir une étendue exacte des inondations dans la région étudiée. Les niveaux d'eau sont généralement présentés comme des hauteurs contre des charpentes et non pas comme l'étendue maximum de l'inondation. Les niveaux d'eau choisis pour définir les repères maximum de crue sont donc fondés sur l'hypothèse que le même niveau d'eau maximum s'appliquerait à toute la région étudiée.

Au cours de cette étude, on a constaté que les niveaux de crue historique maximum dans la ville de Sackville et à Frosty Hollow sont de 7,9 m et 8,0 m, respectivement. On recommande que ces niveaux soient utilisés pour désignés les zones inondables. Il faut se rappeler cependant que ce niveau dépend de l'entretien des digues et des aboiteaux. Une période de récurrence ne peut pas être assignée à ce niveau de crue. Si les digues protégeant Sackville sont rupturées, le niveau de crue pourrait atteindre ou dépasser le niveau historique maximum.

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1.0 INTRODUCTION

1.1 Objectives

The objective of this study is to investigate the nature, history and extent of flooding in the Town of Sackville and the surrounding area including the Tantramar River and Frosty Hollow Brook. The area has a history of flooding which is documented back to 1759 when the first settlers arrived and began to build dykes to protect the low-lying marshlands.

The study reviews the hydrotechnical aspects of the area to evaluate some of the causes of the flooding. Flooding is caused by high tides, heavy rainfall, snowmelt or a combination of these factors. The land is protected by an extensive network of man-made dykes which are equipped with aboiteau (uni-directional pipes equipped with flap gates) to allow river flow and runoff to reach the sea during low tides. A tidal control dam is located at the mouth of the Tantramar River and serves to prevent the high water levels in Cumberland Basin from travelling up the river and flooding land near the river bank.

1.2 Study Area

The study area is comprised of the Town of Sackville and surrounding communities, including Middle Sackville and Frosty Hollow. The study area also includes the flood plains of the Tantramar River and Carters Brook (Figure 1.1).

The Town of Sackville is located in southeastern New Brunswick approximately 10 kilometres (km) from the New Brunswick-Nova Scotia border. The Town is bordered on the east by the Tantramar River which runs into the Cumberland Basin which is an arm of the Bay of Fundy. Frosty Hollow Lake and Brook are located to the southeast. The land in Sackville slopes gently towards the river and generally is low and poorly drained.

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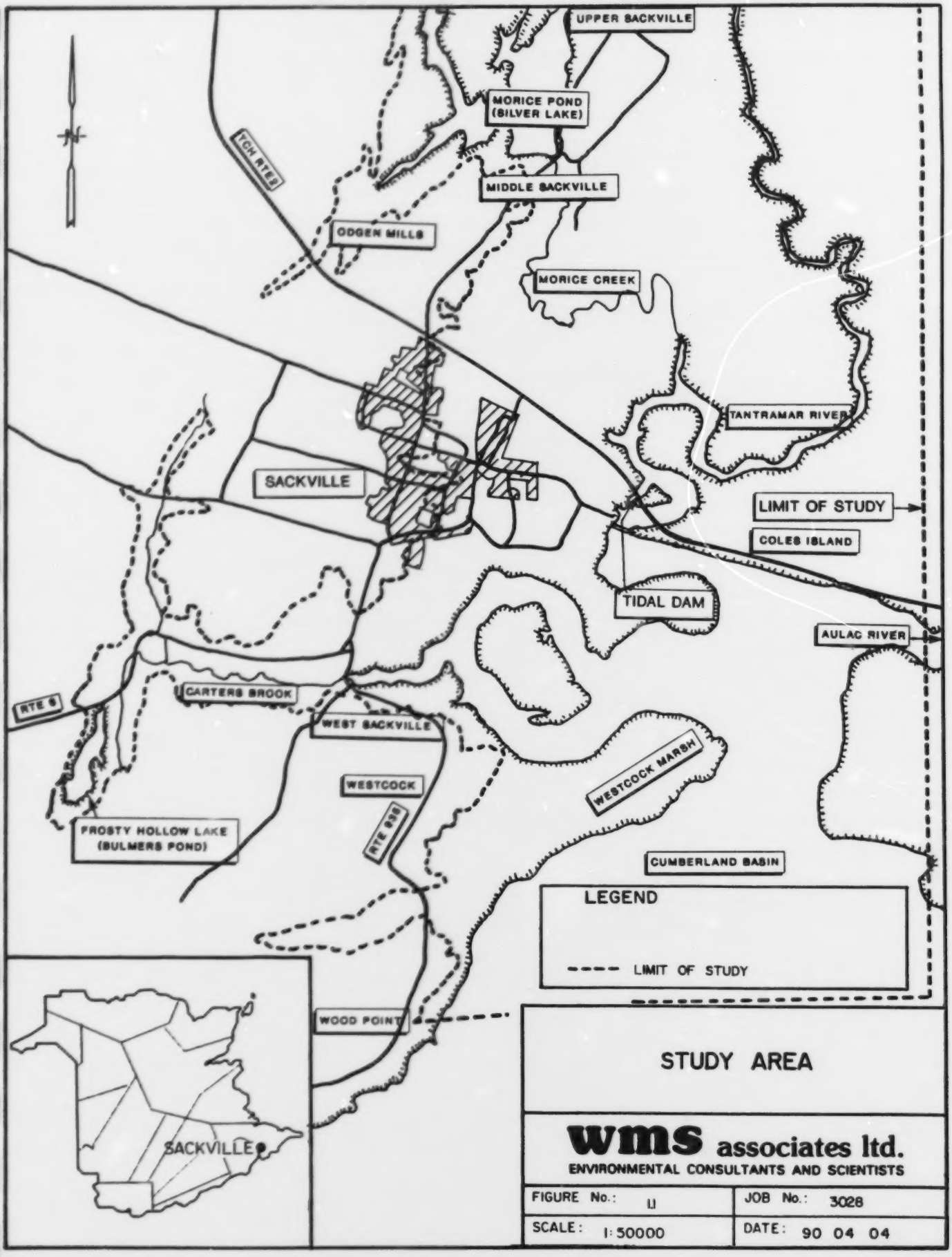

STUDY AREA

wms associates ltd.
ENVIRONMENTAL CONSULTANTS AND SCIENTISTS

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1.3 Methodology and Scope of Work

An initial investigation was conducted of previous reports, photographs, newspapers and historical archives. This investigation provided the dates and brief descriptions of major flood events in the study area. The physical effects and extent of flooding were determined through subsequent field investigations, where possible.

Local residents and officials who have knowledge of past floods were interviewed. A questionnaire (Appendix A) was developed to guide the interviewer, ensuring that interviews were conducted consistently. The objective of the interviews was to identify known flood limits from past events and to obtain available photographic or other evidence of these.

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1.4 Authorization

WMS Associates Limited has undertaken this study for the New Brunswick Department of the Environment, under the Canada - New Brunswick Flood Damage Reduction Program. The study has been completed in consultation with a Technical Committee comprised of representatives from the Inland Waters Directorate of Environment Canada and from the Water Resource Planning Branch of the New Brunswick Department of the Environment.

2.0 FLOOD DOCUMENTATION

This chapter presents both the methodology used in the collection and compilation of flood documentation data, and the methodology used to compile and evaluate the information so that water level reference points could be located in the field. The major flood events in the Sackville area are presented in Section 2.1.

The flood documentation portion of the study included the collection and thorough review of existing information obtained on past floods in the Sackville area. This included archival sources (Section 2.2), and interviews with members of the public using questionnaires (Section 2.3). Photographs of flooded areas were collected from these sources and supplemented by current photographs.

Mapping for the study area was collected and assembled. The entire study area was covered on one 1:50,000 scale National Topographic Series maps (Amherst, 21 H/16). Photocopies of the relevant portion containing the study area were used for reference in the field, and for recording reference point locations for the Field Guide (WMS 1990), which is issued as a supplement to this report. A total of 8 LRIS 1:10,000 scale photomaps were used to locate and record the reference points.

2.1 Past Flooding

The first recorded flood in the Sackville area was in 1759. Four years during the 1800s had recorded floods (mostly in the fall), the most well-known being that caused by the Saxby Gale of October 4, 1869. Barns, fences, haystacks and cattle were reported to have been carried away from the Tantramar Marshes by a tide which was estimated to be 1.8 metres (m) above the highest spring tide ever known.

A total of 40 flood events were recorded during 21 of the first fifty years of the twentieth century. Several of the flood events were described as being the highest since the Saxby Gale of 1869, establishing that event as the reference point for many years. Many of these 40 events occurred in the fall, and were the result of high tides; others resulted from rainstorms causing high runoff, or a combination of rain and melting snow. Table 2.1 presents a list of the known flood events which affected the study area.

TABLE 2.1: FLOOD EVENTS IN SACKVILLE

Flood Date		Flood Date	
1989	Apr 7	1923	Apr 29-May 9
1989	Feb 28-Mar 1	1922	Sep 22-23
1988	Mar 30	1922	Aug 26-27
1979	?	1920	Mar 13
1978	Jan 10-11	1918	Oct 7
1977	Jul 12	1918	Sep 21-22
1976	Feb ?	1917	Nov 1
1971	Feb 15-16	1917	Oct 22
1967	May ?	1917	Oct 1-4
1963	May 1-10	1916	Aug 15
1962	Nov 22-25	1916	Mar 31
1962	Apr 6-7	1916	Jan 7
1962	Apr 6-7	1914	Oct 21
1962	Mar 31-Apr 4	1913	Mar 28-Apr 5
1959	Nov ?	1912	Aug 8-12
1958	Sep 15	1910	Nov 26-27
1953	Feb 7-8	1910	Jul 5
1950	Dec 12-15	1910	Jan 18
1950	Apr 20-24	1909	Oct 1
1945	Jun 23	1903	Jul 25
1945	Jun 12-15	1903	Mar 7
1945	Apr 15-20	1881	Aug 8-9
1940	Sep 16	1881	Sep 8-9
1935	Jan 9-12	1881	May 23
1934	Nov 11	1869	Nov 30
1934	Nov 6	1869	Nov 25
1934	Dec 20	1869	Oct 4-5
1933	Oct 29	1865	Nov 4-5
1933	Oct 25	1800	Dec ?
1933	Oct 6-8	1759	Nov 4
1933	Jun 17-18		
1924	Aug 26-27		
1923	Oct 1		

A total of 18 flood events in 13 years have been recorded since 1950. The most notable of these was the series of floods which occurred in 1962. The "big" flood occurred in late March to early April of 1962 as a result of a "freak" snowstorm in which 0.6 m of snow fell on the area. Heavy snowmelt runoff and high tide contributed to severe flooding of the Town and the marshes. Heavy rains contributed to a second flood a week later. Heavy rainfall also caused flooding in late November of the same year.

Floods in late February of 1989 were described in the media as the worst since the mid-1960s. The contributing factors were high tides, rain and a thaw. Water to a depth of 1.5 m was reported in the basement of the VIA Rail station on Lorne Street.

2.2 Data Sources

Available information on flooding in the Sackville area was collected and reviewed. Two major sources of information were a report on historic floods in New Brunswick, compiled by the Inland Waters Directorate (Kindervater 1985), and a historical flood review of the Town of Sackville, prepared under the Federal-Provincial Flood Damage Reduction Program (Nicholson 1982). Both sources served as a starting point in the search for additional information.

Daily historic streamflow data were obtained for the Petitcodiac River at the Petitcodiac hydrometric gauge (Sta. 01BU002) from the Inland Waters Directorate for the period of record (1961-1988). The Petitcodiac River was used because it was the closest gauged river of similar size. It is also the only nearby river with a continuous record beginning before 1962. Preliminary data for 1989 was obtained to provide information on the antecedent conditions related to the flooding in February 1989. Monthly summaries of streamflow were also obtained for the following stations (IWD 1988):

- Petitcodiac River near Petitcodiac, N.B. (Sta 01BU002);
- Kelley River at Eight Mile Ford, N.S. (Sta 01DL001);
- Turtle Creek near Turtle Creek, N.B. (Sta 01BU003); and
- Palmers Creek near Dorchester, N.B. (Sta 01BU004).

Temperature and precipitation data were obtained from the Sackville meteorologic station (Atmospheric Environment Service 1988). Predicted and recorded tidal levels for the Reference Port of Saint John were obtained for 1989, but historic data prior to 1989 were not available (CHS 1989; D. Spear, pers. comm.).

In the course of the collection of background data, Provincial and Federal government sources were reviewed, including both library and departmental files. Interviews of knowledgeable individuals provided a more focused effort. Government sources included the following:

- New Brunswick Department of Environment, Fredericton;
- New Brunswick Department of Transportation, Fredericton;
- New Brunswick Department of Agriculture, Moncton; and
- New Brunswick Emergency Measures Organization, Fredericton.

The Department of the Environment provided files of newspaper and magazine clippings and reports. The Emergency Measures Organization provided access to reports, and files of photos and clippings.

Libraries and archives were also consulted, as follows:

- Harriet Irving Library, University of New Brunswick, Fredericton;

- Provincial Archives, Fredericton; and
- Mount Allison University library, Sackville.

Various references and photo files were examined at the Mount Allison University library. Microfilms of several Sackville newspapers plus the Moncton Daily Times were examined at the Harriet Irving Library. The Provincial Archives provided both records from the Sackville United Church and the Tantramar United Church and files of historical photos.

The Town of Sackville area has had weekly or semi-weekly newspapers under various names since at least 1865. The following issues were examined:

- The Borderer, 1865-1870;
- Borderer & Westmorland Cumberland Advertiser, 1865-1872;
- Chignecto Post, 1870-1872, 1876-1879;
- Chignecto Post & Borderer, 1879-1896;
- Sackville Post, 1905-1946;
- Sackville Semi-Weekly Post, 1897-1904;
- Sackville Transcript, 1880-1946;
- Sackville Tribune, 1902-1946; and
- Sackville Tribune Post, 1946-1978.

Local floods were either covered extensively in the local weekly newspaper or were given cursory coverage if the event happened several days before the date of issue. The Moncton

Daily Times was consulted for the dates before, during and after each flood event, in order to provide maximum coverage of the event. The larger flood events received extensive coverage from all newspapers but the minor floods received only brief mention.

The Emergency Measures Organization, Provincial Government Departments and the Provincial Archives provided additional background information on flood events but generally did not provide details which could lead to the determination of water levels in the field.

2.3 Interviews and Questionnaires

Historical data, reports and newspaper accounts are valuable for rounding out the background information for flood events, but the majority of actual flood level reference points, i.e., points which can actually be measured in the field, are obtained from personal interviews of local residents. This became apparent during a similar interview phase conducted for a previous study of flooding along the Magaguadavic River at St. George (WMS 1989).

In order to guide the interviewer and to ensure that all interviewees were asked the same questions, a Local Residents And Officials Interview Guide was based on forms developed for the Magaguadavic River Study (WMS 1989). A Flood Event Information Form was also filled out for each flood event described during the interview. Samples of these forms are provided in Appendix A.

A total of 56 interviews were conducted with study area residents between September 21 and 30, 1989; a list of the persons interviewed is included in Appendix B. Initial interviews with the Mayor of Sackville and other Town of Sackville officials provided the first leads for the interviewer, as well as preliminary descriptions of some flood events; subsequent interviews uncovered more leads which were also pursued.

The Interview Guide was also used to provide leads to other residents or officials who might have information on flood events and reference points. The residents were asked general questions on flooding, and specific questions, including dates and locations of specific flood events.

The Flood Event Information Form was completed to obtain information specific to the flood including:

- dates of flood event, including peak and first and last dates (if known);
- type of flood (ice run, ice jam, open water or tidal);
- location of ice runs or ice jams;
- extent, location and height of flood waters;
- direct or indirect damages (type of damage and cost);
- location of any physical evidence of flooding (e.g., high water marks, ice scars or reference points); and
- availability of photographs of the event.

The use of separate questionnaires for each flood event facilitated cross-referencing of interviews for the same flood events. The forms were also useful in:

- maintaining the consistency of the interview method; and
- ensuring that flood details, photographs of the event and leads to additional residents were obtained.

3.0 DATA COMPILATION

The evaluation of the flood data collected during the flood documentation portion of this study is discussed in Section 3.1. Detailed flood descriptions of the three major floods in the Sackville area are presented in Section 3.2. This section also includes a brief description of annual flooding.

The field survey was conducted after the floods were documented and reference points were determined. It was conducted to locate the reference points in the field and measure their elevations, and is described in Section 3.3.

3.1 Data Evaluation

The data collected during the interview survey with local residents and officials were assembled and reviewed. This information was supplemented by information from the archival sources as appropriate. The data were used to produce a list of points for which enough detail was obtained to provide a point in the field at which the level of flooding could be determined. A total of 43 of these "reference points" were obtained. At some of the points, information was obtained on more than one flooding event, so that a total of 58 potential water levels were found.

Not all of the water levels could be determined with the same level of accuracy. Therefore, it was necessary to use a method of ranking the points to allow a comparison to be made of their reliability. The ranking method used was developed for a similar historic flood study for the Magaguadavic River (WMS 1989; Snyder 1989). The following describes the categories used in the ranking system and the corresponding range of elevations. The range of elevation is recognized as being a subjective interpretation of the ranked categories.

- **"Good"** points are the most reliable, and are points for which there is photographic or physical evidence of the maximum flood level;

- **"Reasonable"** points are those for which there is a photograph, but the building has been changed since the photograph was taken; reasonable points

are also those for which a measurement was made by the resident or by others at the time of flooding but the exact reference was not recorded as a physical mark or by photography.

- **"Approximate"** points are levels related to existing structures against which the resident was able to demonstrate an approximate water level; such points are usually those about which the person describing the level had first-hand knowledge.

- **"Vague"** points are flood levels estimated using second hand knowledge or levels in relation to structures no longer in existence.

- **"No Elevation"** is used to designate flood events at a reference point for which commentary is available, but not in sufficient detail to allow a water level to be determined. This category is also used to designate areas or points which are reported not to be inundated during flood events but are located near the flood plain.

A preliminary evaluation was made of these water level reference points. This evaluation was used as a screening process to assign the ranking to the points and to determine which points should be surveyed in the field to provide optimal coverage of the extent of flooding in the study area. It was not possible to survey all of the points found during the research process due to time and budget constraints. The screening process was used to select reliable points which would provide a good spatial coverage of the study area using the most reliable data. In addition, the points were selected to provide a sampling from as many flood events as possible. Table 3.1 presents the results of the preliminary ranking of the reference points.

The preliminary evaluation also considered the type and source of information which was used to obtain the water level at each reference point. The sources of information were classified as follows:

TABLE 3.1: PRELIMINARY RANKING OF POINTS

Point No.	1869	1912	1922	1923	1933	1950	1953	1958	1962	1963	1967	1978	1989	Annual	Point
1	V								A						1
2									R				A		2
3		V					V			V				V	3
4									A						4
5									A						5
6									V						6
7												V			7
8												V			8
9													A		9
10													V		10
11									R				G		11
12													R		12
13									R						13
14		Y			V				R						14
15									A						15
16									V						16
17											R				17
18	V														18
19									R						19
20								A							20
21									V				A		21
22														Y	22
23							V							Y	23
24									A						24
25			Y	Y	Y				A						25
26									R						26
27									A						27
28														A	28
29														Y	29
30														V	30
31														V	31
32											V				32
33	V														33
34														V	34
35		Y							R						35
36									A						36
37									R						37
38									R				R		38
39									G						39
40						Y									40
41									A						41
42									Y						42
43									A						43
Potential Points	3	3	1	1	2	1	2	1	24	1	2	2	7	8	58

Label	Description	Range
G	Good	± 25 mm
R	Reasonable	± 50 mm
A	Approximate	± 150 mm
V	Vague	± 300 mm
Y	No Elevation	

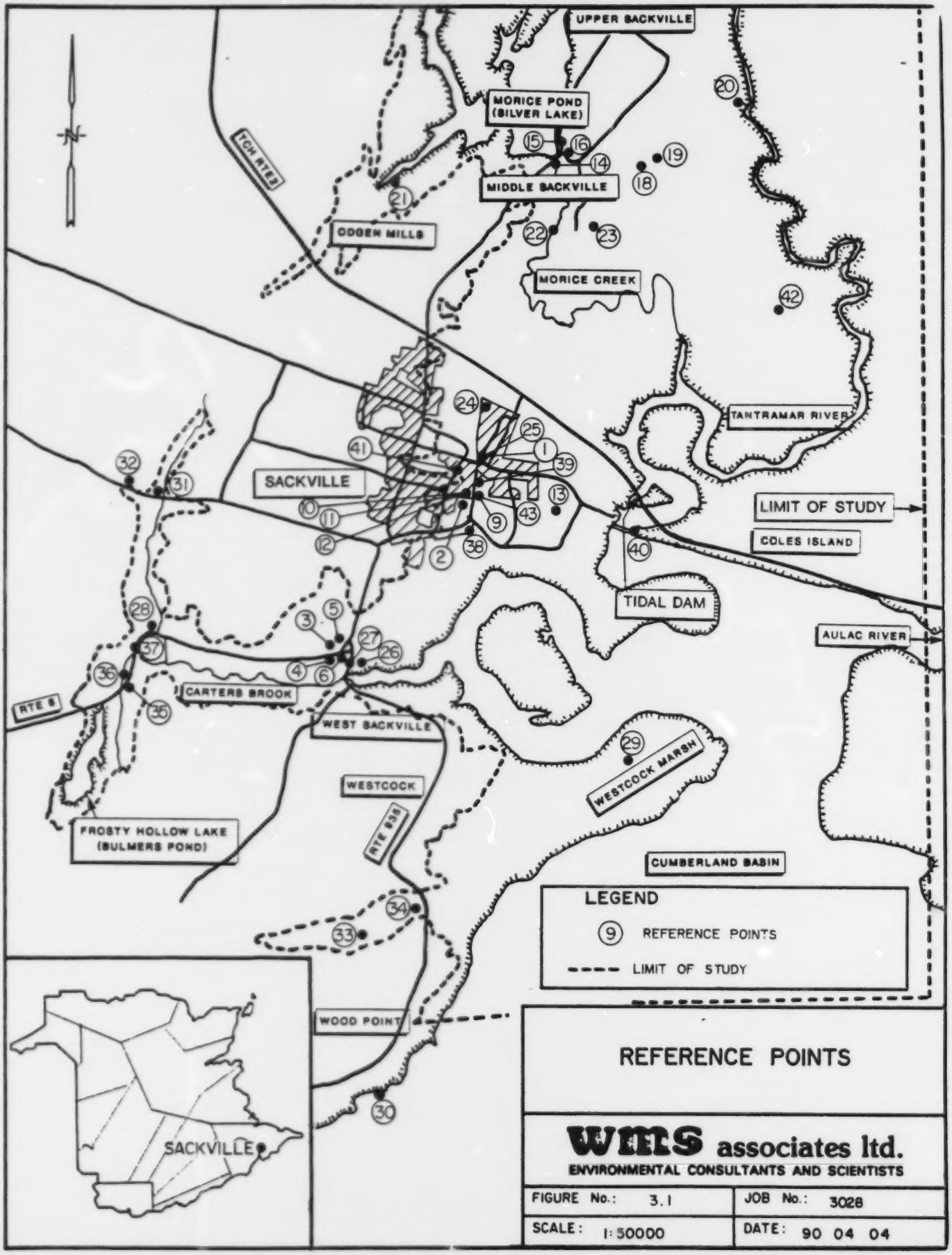
- anecdotal, i.e., verbal description of the event or level;
- newspaper or archival account; or
- photographs taken during the flood event.

All data from the archival research and interview process was collated into a draft "Field Guide" (WMS 1990) which provided the information required to assess the points; it is issued as a supplement to this report. The Field Guide contains the following information:

- reference point number;
- sketch map showing point location;
- description of reference point location, and water level(s) at the point;
- photograph(s) of the water level during the flood event (if available); and
- current photograph(s) of the reference point as it now appears showing the water level and how the structure or site appears from the nearest road.

The Field Guide was used by the survey crew to locate the points in the field during a field reconnaissance following the preliminary assessment. The field guide included the ranking of each point with additional information to indicate the location of the water level measurement. The practicality of surveying the indicated reference points was also assessed during the field reconnaissance.

The objective of the study was to survey a total of 30 reference points in the field. The preliminary screening process and reconnaissance visit were used to determine which of the 43 reference points found during the research portion of the study should receive priority for surveying in the field. The approximate locations of the reference points are shown in Figure 3.1.



REFERENCE POINTS

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FIGURE No.: 3.1	JOB No.: 3028
SCALE: 1:30000	DATE: 90 04 04

3.2 Flood Descriptions

There have been three major flooding events in the Sackville area within recent memory; these were:

- the Saxby Gale of 1869;
- the flooding of 1962; and
- the flooding of 1989.

These are described in the following sections.

3.2.1 Saxby Gale (1869)

On October 4 and 5, 1869, a severe storm occurred which, combined with extraordinarily high tides, caused destruction and death along the Bay of Fundy (Desplanque 1982; 1989). The storm is known locally as the "Saxby Gale", and is named after Lieutenant Saxby of the British Navy who had predicted the event to the day one year before. Saxby had postulated that an eighteen year tidal cycle influenced by the passage of the moon would be at its peak on that date and that it would be combined with a storm to produce storm tides of great proportions. He did not pinpoint any locations for this combination of events. History shows that such a storm and high tide did occur in the Bay of Fundy and that it did cause severe destruction and death.

The following appeared in a ledger belonging at one time to W. K. Bowser, Sackville, N.B.; the original is now owned by Mrs. Ken Fillmore of Sackville.

> **The storm commenced at 9 o'clock on Monday evening Oct. 4, 1869. In the morning all was quiet but rather foggy; people looked toward their marshes with silent amazement. The total loss on the Sackville Marshes is estimated at $81,000.00.**

Barns, fences, haystacks and cattle were carried away from the marshes. "The tide wave [tidal elevation] was estimated to be six feet [1.8 m] above the highest spring tide ever known. Water covered the station house floor to a depth of six inches [150 mm]." (The Borderer, Oct. 7, 1869). Mr. Mitchell Smith, resident of Sackville, recalled a story which said his grandfather had been stranded in Fort Lawrence during the Saxby Gale so that he could neither cross the marsh to Sackville nor to Amherst.

High tide measurements associated with the Saxby Tide have been erroneously reported in the literature due to a misinterpretation of the original measurements (Desplanque 1982). These erroneous figures reported that the previously known high tides in the Minas Basin were known to be 14 m to 15.8 m above low water, but that the Saxby Tide rose to 31.4 m. The misinterpretation involved the establishment of a temporary bench mark at 30.5 m (100 ft), in relation to which the measurement of 31.4 m was taken. The lowest low water tide at spring perigee was 14 m. The difference between the Saxby Tide and the lowest tide observed in the Minas Basin was thus 17.4 m.

In the course of this study, three reference points were found relating to the 1869 flood. The descriptions of the flooding at these points were vague and did not produce reliable water levels for use in delineating the extent of flooding in 1869.

3.2.2 Flooding of 1962

A snow fall, unusually high tides and torrential rainfall between March 31 and April 4, 1962 resulted in "... the entire section of town east of Main St." being "... under various depths of water" (The Moncton Daily Times, April 3, 1962). Hardest hit were areas along Lorne St., Dufferin St. and Wellington St; Black's Hardware and Chignecto Bakeries on Lorne St. sustained considerable damage (Figure 3.2 and 3.3).

At Middle Sackville, Silver (Morice) Lake overflowed its banks, flooding homes and businesses in the area. A section of the road bed was washed out from under a CNR train at College Bridge. At Frosty Hollow, flood waters were flowing along the CNR track forming an "arc-like lake of some three miles in length" (The Moncton Daily Times, April 3, 1962). Motors in the sewage pump house were under 4.6 m of water at one time during the flood (The Moncton Daily Times, April 6, 1962). Damages were estimated at $197,000, including loss to business and industry at $175,000, loss to municipal property at $12,000, and loss to private homes at a minimum of $10,000 (The Tribune Post, May 3, 1962).

Observers noted that the tide came in and held the water, which backed up into Frosty Hollow for 6 hours, before the tide went out and the water started to go down; the marshes were flooded for days (John H. Tapley, pers. comm.).

The dam at the Silver Lake outlet regulates the amount of water flowing out of the lake and onto the marsh east of the dam. Each spring, waters run off the higher land north and west of the lake, causing it to rise. The increase in the volume of water in Silver Lake results in more water entering Morice Creek, which fills its banks and overflows onto the marsh, flooding fields and roads on the marsh (Geraldine Trenholm, pers. comm.). Springs

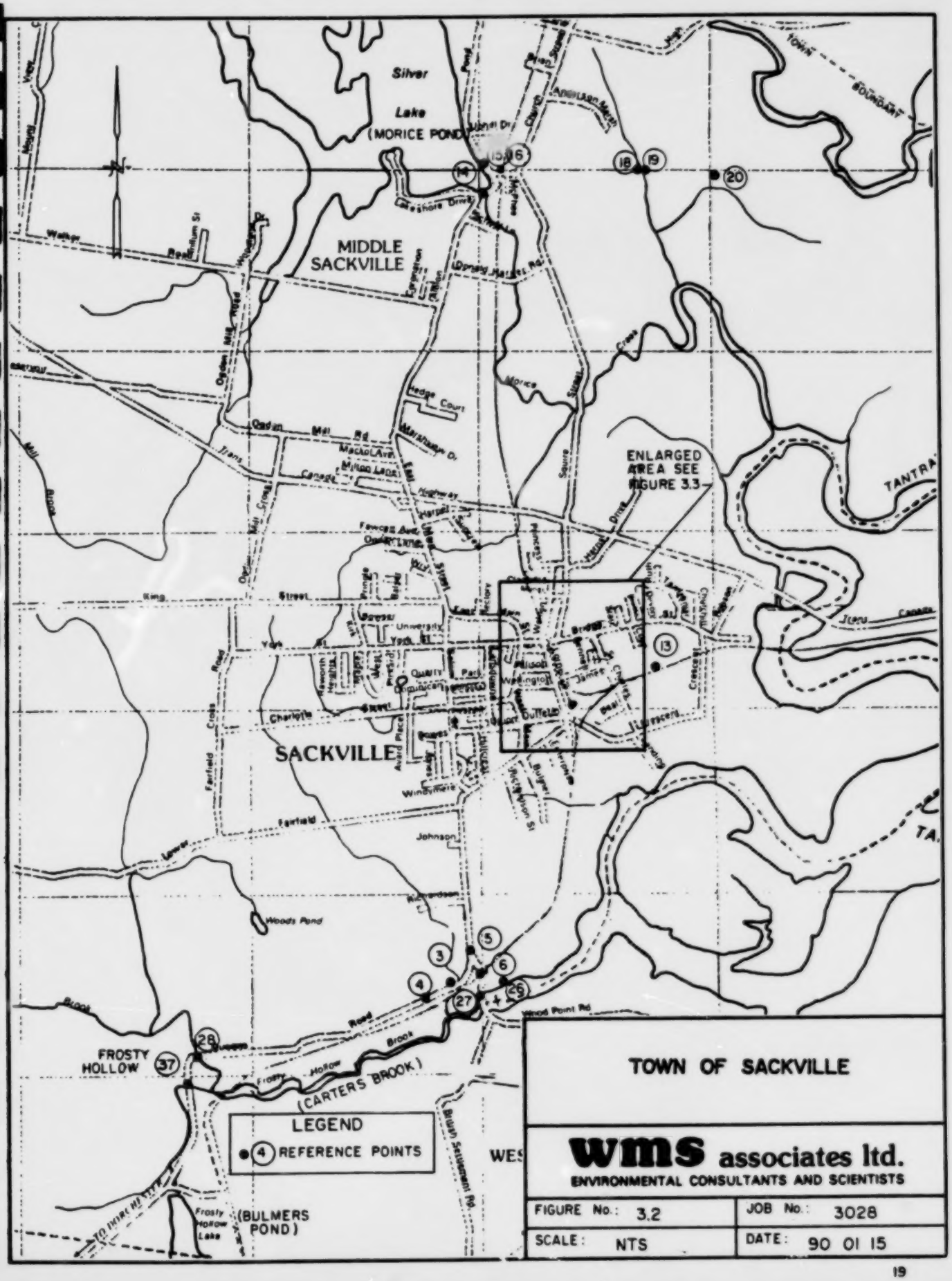
Silver
Lake
(MORICE POND)
MIDDLE
SACKVILLE
SACKVILLE
ENLARGED
AREA SEE
FIGURE 3.3
TOWN OF SACKVILLE
Woods Pond
FROSTY
HOLLOW
(CARTERS BROOK)
(BULMERS
POND)
LEGEND
4 REFERENCE POINTS
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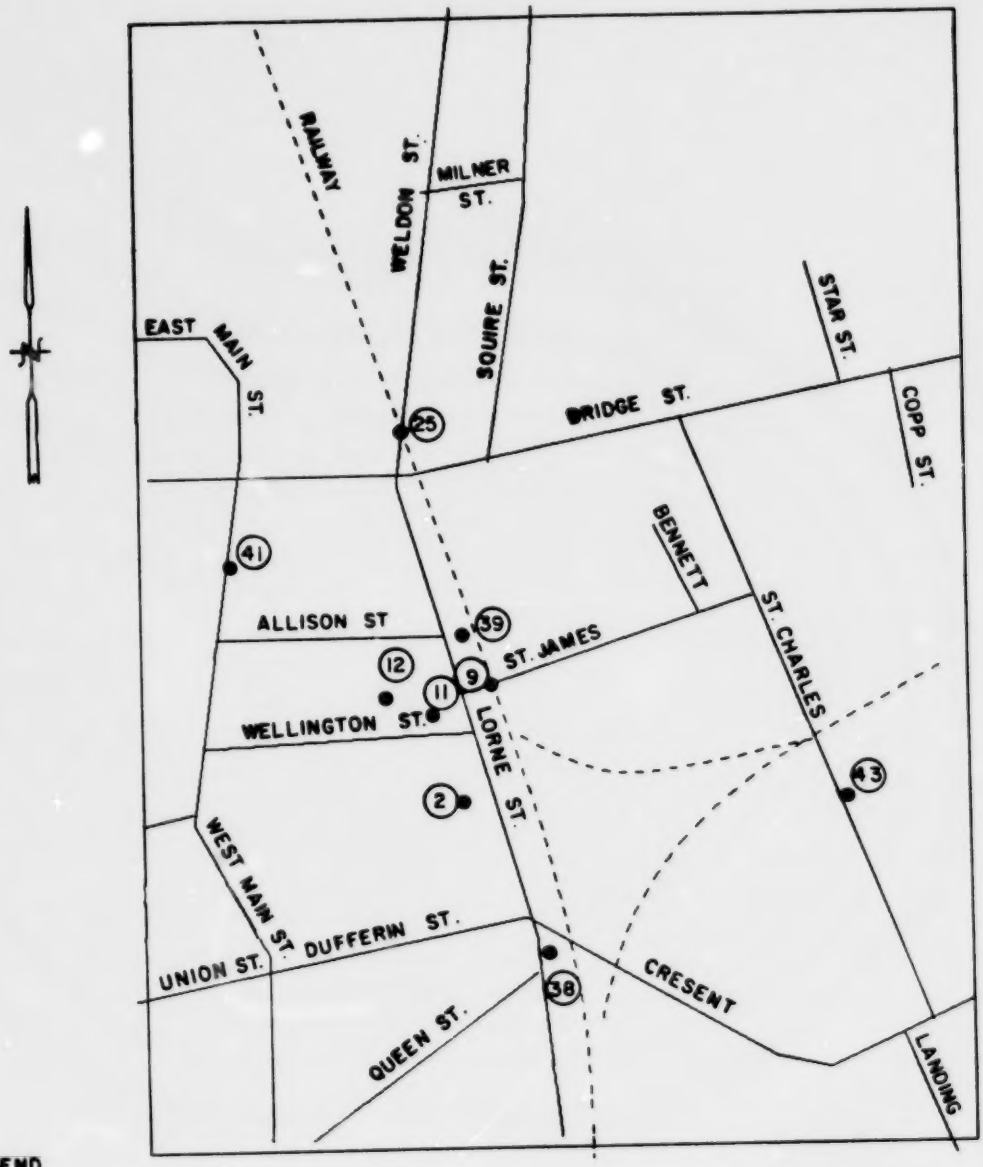
FIGURE No.: 3.2
JOB No.: 3028
SCALE: NTS
DATE: 90 01 15



LEGEND

(1) REFERENCE POINT AND NUMBER.

— ROAD

- - - RAILWAY

DOWNTOWN SACKVILLE

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FIGURE No.: 3.3	JOB No.: 3028
SCALE: NTS	DATE: 90 03 03

with exceptionally high run off and rainfall, such as 1962, result in more widespread effects, including the flooding of homes and businesses in Middle Sackville, and damage to the highway and railway lines.

Prior to 1962, Aboiteau NB37-10 (Figure 3.4) consisting of three 910 millimetre (mm) diameter pipes controlled the drainage of the Frosty Hollow area west of Sackville. With normal spring runoffs Aboiteau NB37-10 was capable of functioning properly.

In spring of 1962 however, unusual weather conditions were experienced. It was reported that 600 mm of very wet snow was followed by heavy rainfall (John H. Tapley, pers. comm.). The flow capacity of Aboiteau NB37-10 could not pass the abnormally high runoff and the water level began to build up behind it. Water flowed over roads and the railway flooding all the surrounding low lands. As the tides came in, all drainage through Aboiteau NB37-10 ceased and water continued to build on the west side of the Westcock highway (Highway 935). Water flowed over the highway flooding fields east of Highway 935 on both sides for the CNR mainline. The flood water then, according to Ben Johnson, (pers. comm.), followed the north side of the CNR mainline into the Town of Sackville stressing its already taxed drainage system. Flood water rose as far as Lounsbury's on Bridge St. flooding all homes and businesses in the Lorne St. area. (Figure 1.1 and 3.2)

After the devastation of the 1962 flood, it was realized that the size of the opening of Aboiteau NB37-10 was insufficient. An additional aboiteau measuring 1830 mm by 1830 mm was installed at Westcock in 1965. Since the installation of the new aboiteau, local residents (Otis Campbell, Ben Johnson, Keith Carters, pers. comm.) state there have been no more problems with flooding in that area.

One week after the "big" 1962 flood on April 6-7, runoff from a heavy rainfall combined with tide water entering through some of the broken dykes along Highway 106 caused a second flood. Middle Sackville was still flooded at the time of the second flood in Frosty Hollow (A. Ayer, pers. comm.). This second flood was also noted by Kindervater (1985) who stated that basements were flooded in the town. St. James, St. Charles, and Lorne Streets were inundated, and the lower lying marshlands were also flooded (Figure 3.2).

A third period of flooding occurred between November 22 and 25, 1962, when a heavy rainstorm was experienced in the Maritimes (Kindervater 1985). Flooding of the pumping station contributed to water depths of 150 mm to 200 mm on Lorne Street (The Moncton Daily Times, Nov. 23, 1962). The heavy rainfall contributed to flooding to a depth of nearby 600 mm on Highway 2 at Frosty Hollow (The Tribune Post, Nov. 29, 1962).

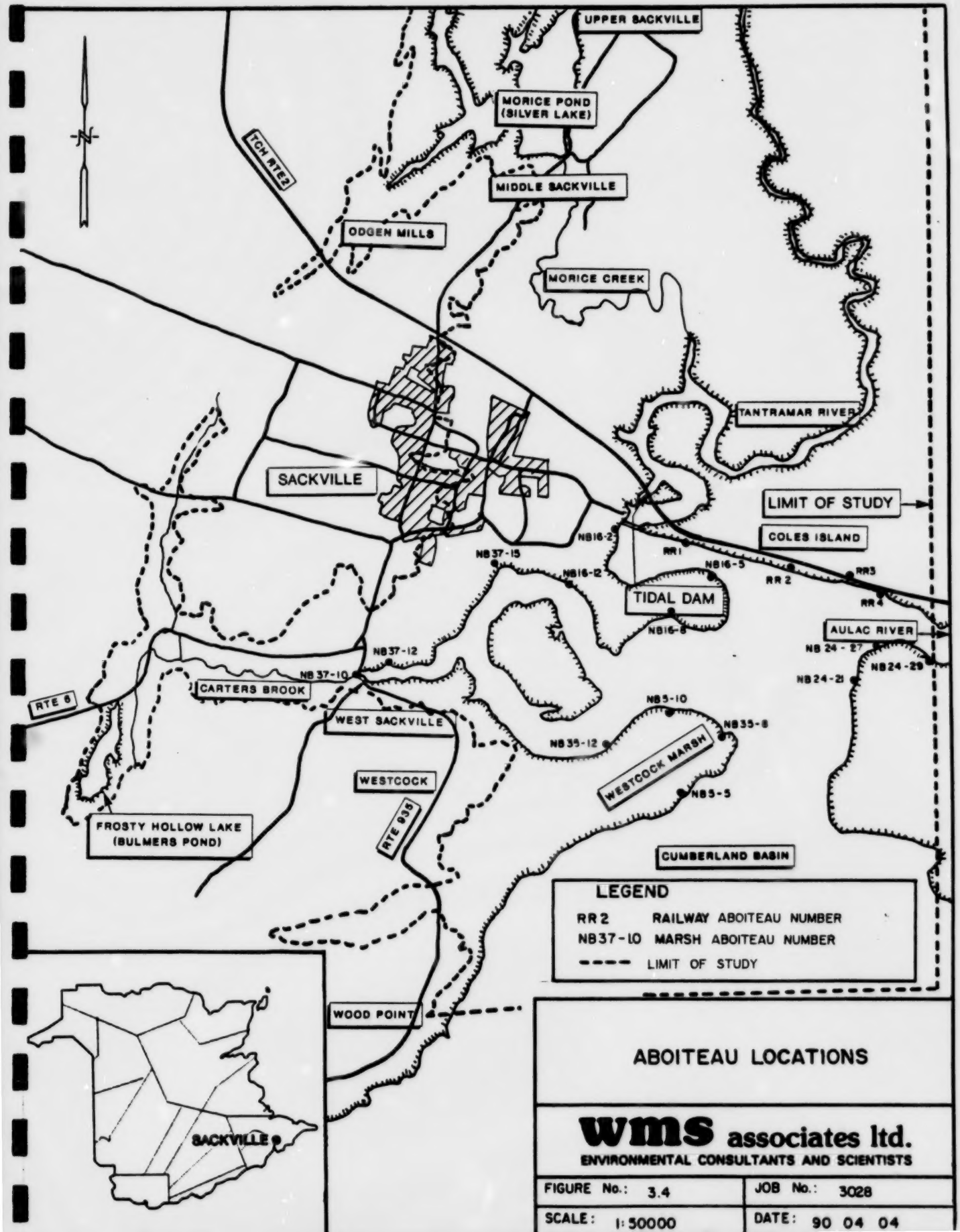
UPPER SACKVILLE
MORICE POND (SILVER LAKE)
TCH RTE 2
MIDDLE SACKVILLE
ODGEN MILLS
MORICE CREEK
TANTRAMAR RIVER
SACKVILLE
LIMIT OF STUDY
COLES ISLAND
NB16-2
RR1
NB37-15
NB16-5
RR2
RR3
NB16-12
TIDAL DAM
RR4
NB16-8
AULAC RIVER
NB 24 - 27
NB37-12
NB24-29
NB37-10
NB24-21
CARTERS BROOK
RTE 6
NB5-10
NB35-8
WEST SACKVILLE
NB35-12
WESTCOCK MARSH
WESTCOCK
NB5-5
RTE 935
FROSTY HOLLOW LAKE (BULMERS POND)
CUMBERLAND BASIN
WOOD POINT
SACKVILLE
LEGEND
RR2 RAILWAY ABOITEAU NUMBER
NB37-10 MARSH ABOITEAU NUMBER
LIMIT OF STUDY
ABOITEAU LOCATIONS
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FIGURE No.: 3.4
JOB No.: 3028
SCALE: 1:50000
DATE: 90 04 04

The majority of the water level reference points found as a result of the research in this study, related to the March 31 to April 4, 1962 flood. Photographs and home movie film were collected which depict the nature and extent of the flooding in Sackville and the surrounding area. A total of 24 water level points were found for this flood. The locations of these points are shown in Figure 3.5.

3.2.3 Flooding of 1989

The worst flooding since the mid 1960s occurred February 28 to March 1, 1989 (The Sackville Tribune Post, March 1, 1989). High tides, rain and thaw combined to cause severe flooding in the Lorne St. and Charles St. areas. Water to a depth of 1.5 m was reported to be in the basement of the VIA Rail station on Lorne St.; numerous other basements were also flooded. Water reached the level of the bottom shelving units in Lockharts Beaver Lumber on Lorne St.; Charles St. was flooded with about 300 mm of water.

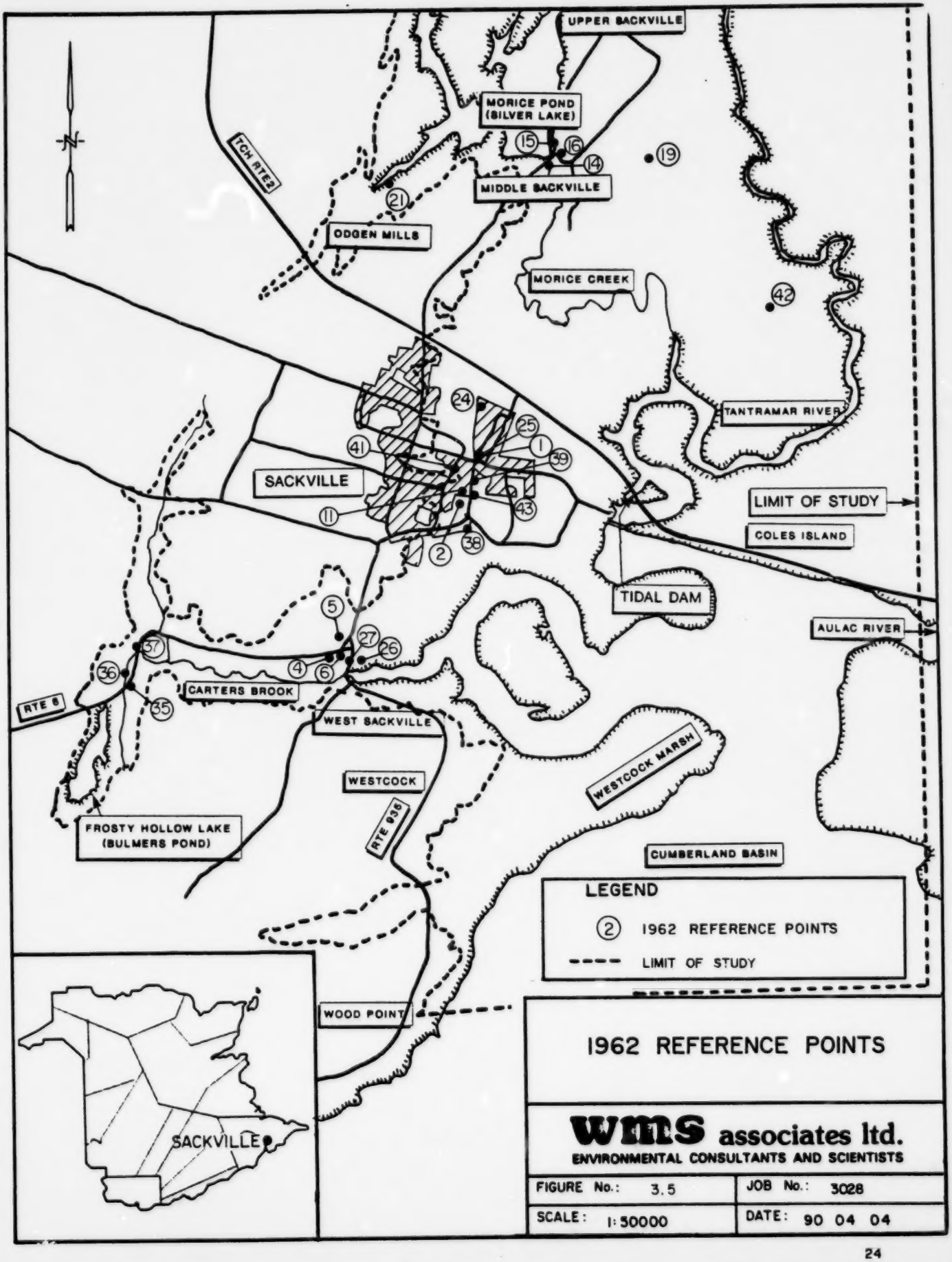
There was a localized flood March 16, 1989 on Wellington St. beside Lockharts Beaver Lumber (A. Cormier, Manager of Lockharts Beaver Lumber on Lorne St., pers. comm.). Flooding caused by heavy rains and runoff began at 9:00 a.m. Town pumping crews were called in to remove the water but at 6:00 p.m. the tides were high and water was again rising. Water reached a depth of 450 mm to 600 mm on Wellington St., but by 11:00 p.m. the water level had fallen. No damage was sustained by Lockharts.

A total of 7 water level reference points were found for the February 28 to March 1, 1989 flood. The location of these are shown on Figure 3.6. These points were all located within the Town of Sackville, and it appears that flooding in 1989 was restricted to that area. Some photographs were collected which help to show the extent of flooding in 1989.

3.2.4 Annual Flooding

Some portions of the Sackville area are subject to minor flooding on an annual basis.

Each spring, runoff from the higher land north and west of Silver (Morice) Lake causes flooding in the study area. The increase in the runoff entering Silver Lake results in more water being discharged into Morice Creek. With increased flood flow, its banks are filled and overflow onto the marsh. Fields and roads on the marsh are flooded (Geraldine Trenholm, pers. comm.).



1962 REFERENCE POINTS

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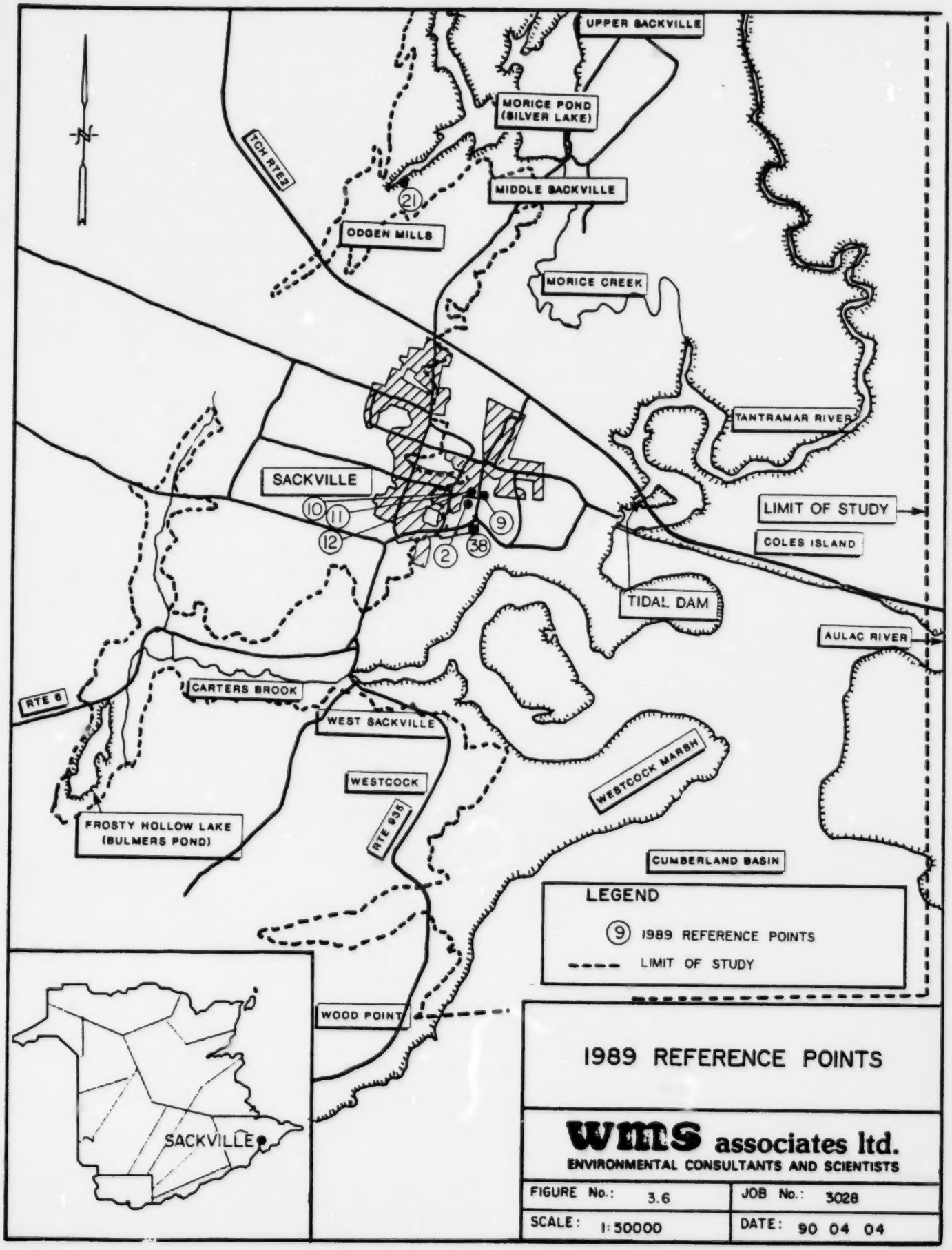
FIGURE No.: 3.5	JOB No.: 3028
SCALE: 1:50000	DATE: 90 04 04



1989 REFERENCE POINTS

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FIGURE No.: 3.6	JOB No.: 3028
SCALE: 1:50000	DATE: 90 04 04

Runoff from the land lying north of the Lower Fairfield Road (Figure 3.2) flows under the Fairfield Road, 2.5 km and 2.75 km west from the intersection Highway 106 and the Lower Fairfield Road. Prior to the road being raised and paved in the late 1960s, the road flooded each spring at the culvert located 2.75 km west of the intersection. The present culvert passes the runoff without any flooding.

There are some problems with the culvert under the Lower Fairfield Road 2.5 km west of the previously mentioned intersection. Mrs. Donald Bulmer (pers. comm.), remarked that each spring the culvert is filled to within 300 mm of the top. Harold Turner (pers. comm.) remarked that he has seen the water backup on the north side of the culvert and flood into the bushes 15 m north of the road.

Flooding commonly occurs in the marshlands east of Highway 935 at Wood Point (Figure 1.1). These fields have been flooding regularly since 18th century Acadian dykes have fallen into disrepair. It is common for tidal waters to reach the Wood Point upland when there is a high tide and a strong wind (Roy Snowdon, pers. comm.). The Wood Point upland can be identified by a change in soil type; a rough approximation of the flood line can be seen in the field by the lower edges of the farm fields.

"When the ice comes out of Silver Lake, the marsh at the end of Harper Road floods every year. The water is on the road at both ends of the bridge but it is always passable with cars" (G. Trenholm, pers. comm.).

A total of 8 water level reference points were found for annual flooding in the study area. In most cases, the descriptions of the annual flooding were not sufficiently detailed to allow a reliable water level to be determined. The water levels for two of the annual flooding points were measured during the field program. The water levels reached on an annual basis are well below those of the extreme events noted in Sections 3.2.1 to 3.2.3. The annual flooding does not affect any houses in the study area, but may cause minor problems with the road network at bridges or low-lying sections of roads.

3.3 Field Survey

The details of the data collected by the surveyors during the field program is included in a separate report which provides the supplementary information for this study (Geoplan 1989). This includes the field notes taken during the survey and the descriptions of the bench mark locations. Table 3.2 presents the elevations and locations of the reference points found during the study. These were used to determine the flood levels for the identified flood events. Horizontal and vertical location was determined for all points

TABLE 3.2: ELEVATION AND LOCATION OF REFERENCE POINTS

Point No.	Northing	Easting	Elevation
1	734,231.25	465,588.49	7.57
2	734,823.23	465,506.45	8.18
3	733,154.38	464,165.88	6.51
4	733,130.54	464,072.64	7.02
5	733,369.37	464,323.78	8.02
6	733,193.74	464,330.64	8.18
7*			
8*			
9	734,947.40	465,584.53	6.68
10*			
11A	734,942.13	465,508.67	6.48
11B	734,934.56	465,526.42	7.63
12	734,956.34	465,489.35	6.49
13	734,811.88	466,342.01	6.83
14	738,567.50	466,265.60	8.63
15	738,687.56	466,308.66	8.55
16	738,694.64	466,373.57	9.41
17	738,374.92	464,727.21	8.38
18	738,709.99	467,213.53	6.55
19	738,696.70	467,305.93	6.70
20	739,134.07	468,229.49	7.28
21*			
22*			
23*			
24	735,901.97	465,639.91	5.95
25	735,284.56	465,577.90	7.47
26	733,060.83	464,405.02	7.77
27	733,095.49	464,323.87	7.68
28	733,334.74	462,240.71	7.16
29*			
30*			
31*			
32*			
33*			
34*			
35	732,468.26	461,704.74	14.01
36	732,553.50	461,743.54	10.27
37	733,176.49	462,092.30	8.09
38A	734,642.62	465,535.73	7.38
38B	734,644.38	465,537.38	6.40
39	735,025.94	465,559.57	7.93
40*			
41	735,158.07	465,354.13	9.84
42*			
43	734,688.64	465,957.65	6.79

* Point not surveyed.

during the survey. A schematic of the survey route and closures obtained is shown in Figure 3.7.

3.3.1 Horizontal Control

The horizontal position of a number of flood level marks was accomplished by establishing New Brunswick Stereographic grid coordinates for points identified. The New Brunswick coordinates were obtained from the various New Brunswick Monuments in the study area using a Wild T-1600 Total Station and target system. A closed traverse was run along Lorne Street (Figure 3.2) to provide temporary control for the reference points in that area. The control hubs were nails set in asphalt with a traverse precision of 1/9042.

3.3.2 Vertical Control

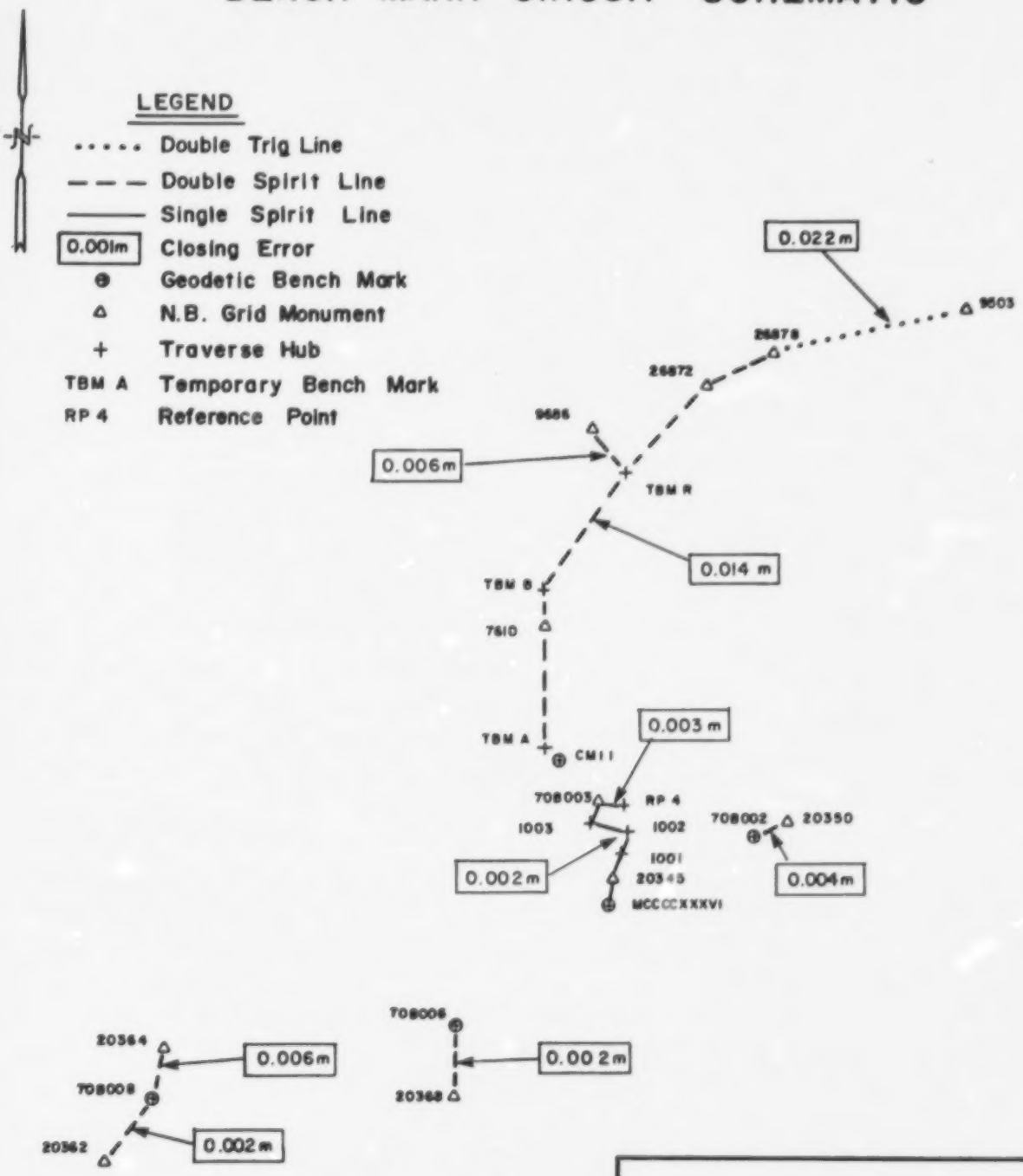
None of the New Brunswick Monuments in the area were considered adequate for vertical control. Consequently all elevations were established using a combination of spirit levelling and trigonometric levelling based on bench marks established by the Geodetic Survey of Canada.Geodetic elevations were established on selected control stations with closed spirit level loops. The closing errors on these level loops were all less than 10 mm. The Geodetic elevation for New Brunswick Monument #9503 was established using Trigonometric levelling with the T-1600, using both forward and reverse sightings from New Brunswick Monument #26878 for which a geodetic elevation was established by spirit levels. The elevations for the flood reference points were established using trigonometric levelling from the selected control stations.

4.0 HYDROTECHNICAL CONSIDERATIONS

This section of the report discusses the factors which may have an effect in causing or increasing the severity of flooding in the Sackville area. The investigation of past flooding in the area has shown that flooding is relatively frequent, although major flooding is infrequent. Flooding appears to be related to the following factors:

- high tide levels;
- high runoff; and
- poor drainage.

BENCH MARK CIRCUIT SCHEMATIC



SACKVILLE BENCH MARK CIRCUIT SCHEMATIC

wms associates ltd.
ENVIRONMENTAL CONSULTANTS AND SCIENTISTS

FIGURE No.: 3.7	JOB No.: 3028
SCALE: NTS	DATE: 90 04 02

SOURCE : GEOPLAN 1989

A combination of these factors can occur causing an increase in the severity of floods in the Sackville area. Sackville is situated in an area of low lying maritime marshland which is protected by dykes. The dykes prevent the high tides from the Bay of Fundy from inundating the area with salt water on a regular basis. The dykes are equipped with flap gates or aboiteau which allow for river flow and local drainage through the dykes during low tide. They close against the high tides to prevent salt water from entering the area through the dykes.

Problems can arise if the tidal levels, in conjunction with wind driven waves, overtop the dykes. If the runoff from the area is very high during the spring melt period, the quantity of runoff can be too high to completely drain during low tide before the aboiteau close on the rising tide. In such cases, all runoff collects at the upstream side of the dykes until the next low tide. In addition, if the aboiteau are undersized or clogged with debris, runoff arriving at the dyke may not be able to exit to the sea before the tide closes the gate. A schematic of the study area drainage is presented in Figure 4.1, which shows how the area is drained and the type of structures in place.

This section of the report presents details of the quantity of runoff, and its current routing and handling. The size and capacity of the aboiteau in the area is also discussed.

4.1 Distribution of Flooding

The earliest recorded flooding in the Sackville area occurred in November, 1759 since that time there have been 62 recorded flood events (Table 2.1). A total of 61 events have occurred since 1860, and in some years, more than one flood has occurred. Examination of the distribution of the flooding shows that flooding can occur in any month of the year (Figure 4.2). Events seem to be concentrated in the fall period when 25 of the events have occurred (Figure 4.3). There is also a concentration of events occurring in the spring period, which could be linked to high runoff due to high rains and snowmelt; 14 of the events occurred in this period. In 1960, the tidal dam on the Tantramar River was completed. This dam is used to control the water levels on the Tantramar River and prevent flooding of the Tantramar Marsh by salt water at high tide. The events recorded since 1960 have been predominantly due to spring flooding, with 6 of the 12 events occurring in the spring.

Figure 4.1 Schematic of Study Area Drainage

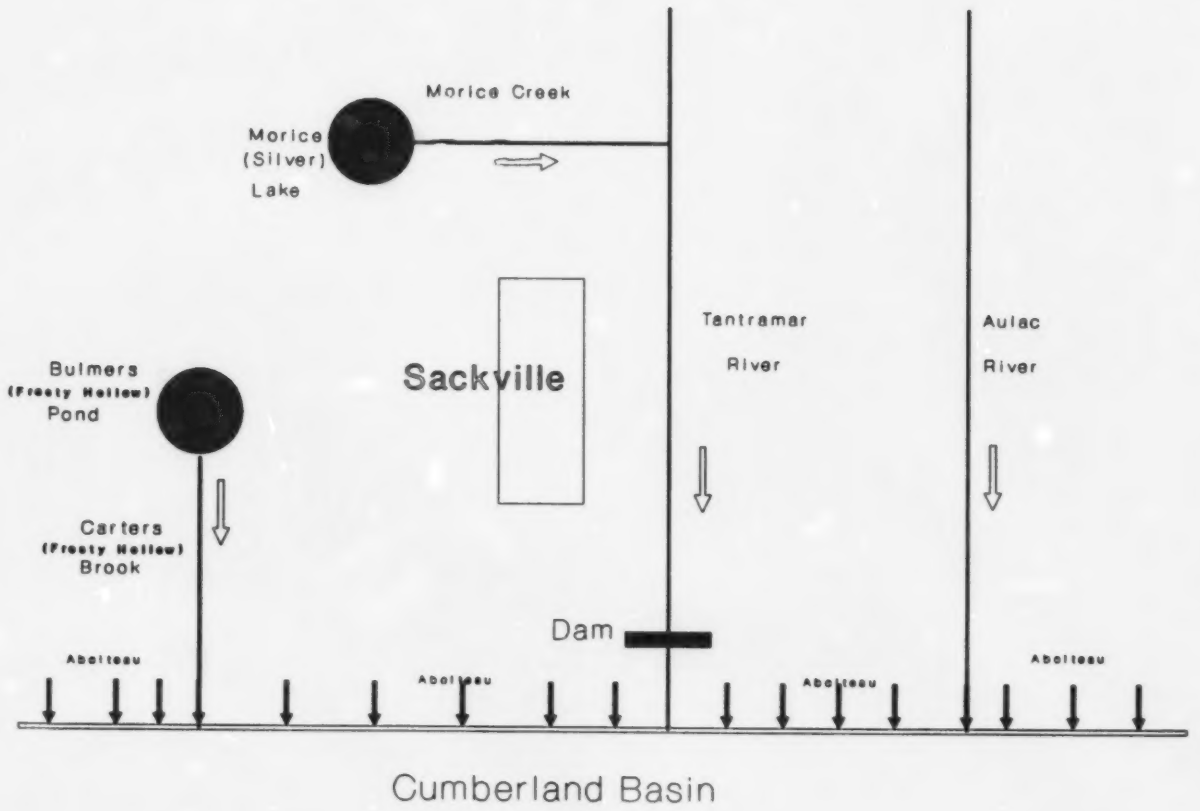


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Figure 4.2 Temporal Distribution of Flooding since 1860

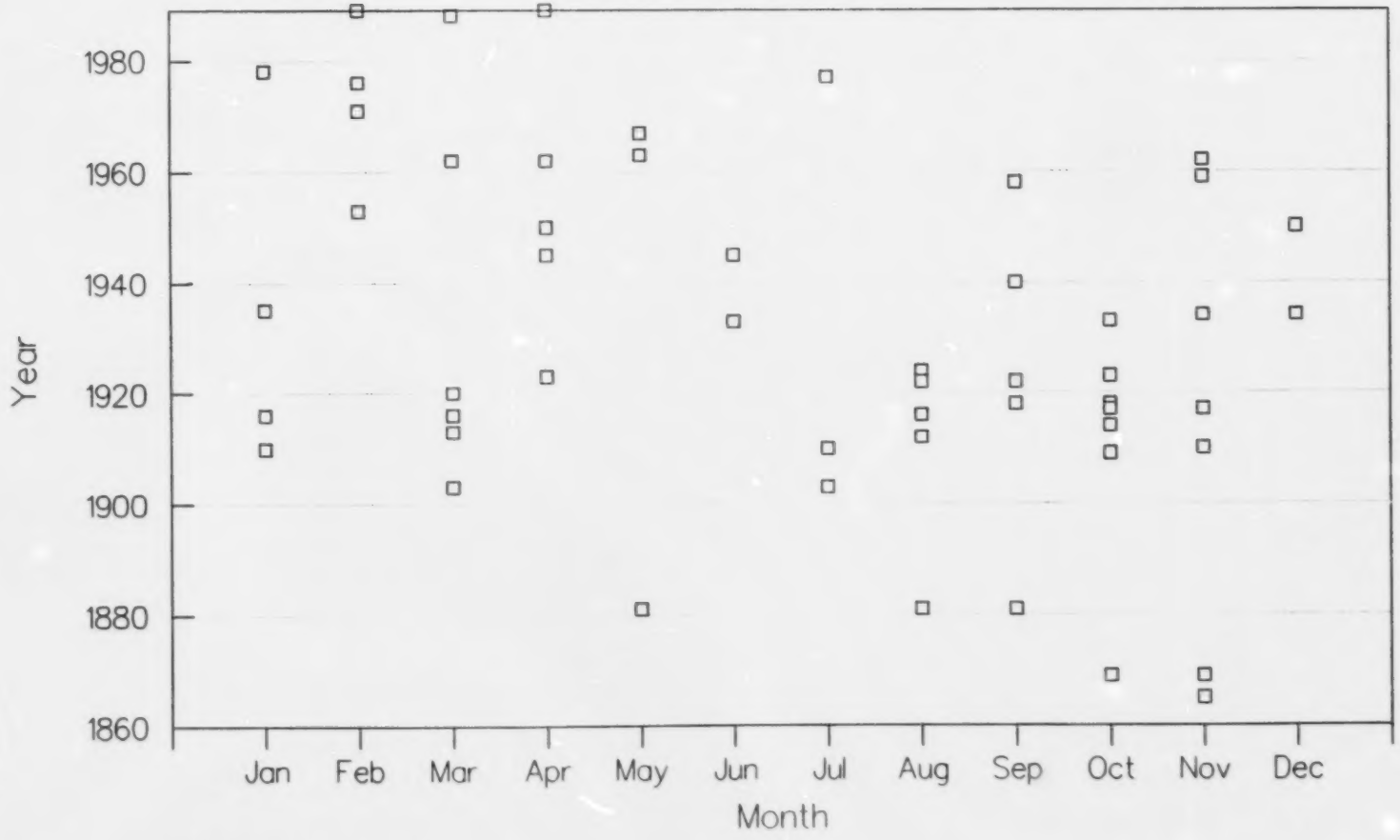

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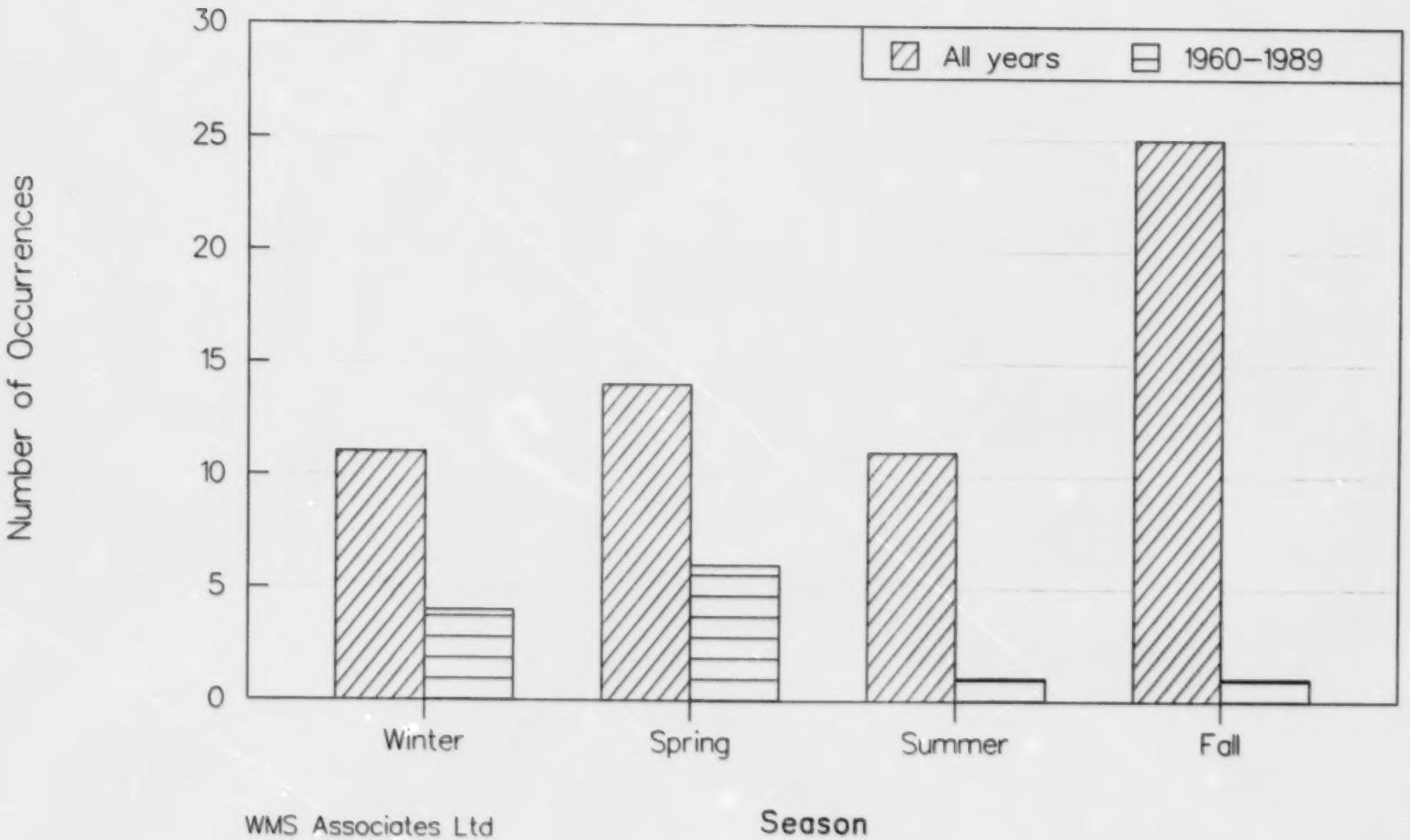
Figure 4.3 Distribution of Flood Events by Season



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A seasonal breakdown has been used in this analysis (Figure 4.3); the seasons have been defined as follows:

- Spring (March 1 to May 31);
- Summer (June 1 to August 31);
- Fall (September 1 to November 30); and
- Winter (December 1 to February 28).

In the 1950s a program of dyke and aboiteau reconstruction was undertaken. At this time the Tantramar Dam was constructed and aboiteau were repaired or replaced. It appears that the Tantramar Dam has been effective in reducing the danger of flooding due to fall storms. The spring flooding has the additional problem of high runoff in combination with tidal elevations which close the aboiteau and prevent outflow of flood waters from the area. Both the 1962 and 1989 floods were due to high runoff caused by rapid snowmelt and high rainfall. The tide closed the aboiteau and preventing runoff to the sea.

4.2 Hydrologic Factors

4.2.1 Drainage Areas

The major watercourse in the study area is the Tantramar River (Figure 1.1). Carters Brook which flows through Frosty Hollow, is also within the study area. The drainage area of these rivers is as follows:

- Tantramar River, 238 km^2; and
- Carters Brook, 39.5 km^2.

The Tantramar River is controlled at its mouth by a tidal control dam. This dam is operated to prevent the high tidal levels of Cumberland Basin from carrying upstream and causing inundation of the dykelands. The gates are opened on the falling tide to allow the normal river flow to reach the basin. The Tantramar River is also controlled further upstream by a small dam on the Morice River, a tributary of the Tantramar. This dam is located at the outlet of Silver (Morice) Lake (Figure 1.1). Carters brook is controlled at its mouth by Aboiteau NB37-10, which prevents the inundation of the Carters Brook flood plain during high tides on the Cumberland Basin.

4.2.2 Flow Estimates

The flow on the Tantramar River at the tidal control dam has been calculated for the 1 in 20 and the 1 in 100 year floods using regional flood frequency analysis (DMAE and IWD 1987). The results of this analysis have been compared to a single station frequency analysis undertaken for the following nearby rivers:

- Petitcodiac River (Sta. 01BU002);
- Kelley River (Sta. 01DL001);
- Turtle Creek (Sta. 01BU003); and
- Palmers Creek (Sta. 01BU004).

The single station frequency analysis was conducted using the program CFA88 (IWD 1988) and reported in DMAE and IWD (1987). Table 4.1 shows the drainage areas for these basins and the peak runoff for the 1 in 20 and 1 in 100 year events.

The flows from these rivers are compared on a unit flow basis (flow per unit area) in Table 4.2 and showed that the Petitcodiac River has a smaller runoff per square kilometre than the other rivers in the area. The other rivers show a much smaller variation in the unit runoff and have been used to compare the flows calculated by the region methods. For all methods, the instantaneous peak flow has been used. The ratio of daily flow to peak flow has been estimated using regional equations for the Southern Hydrologic Region of the province, as defined by DMAE and IWD (1987).

The Petitcodiac River has the largest drainage area of the above rivers, and is classified as being in the "Eastern" Region of the province for the purposes of regional analysis (DMAE and IWD 1987). The Tantramar River is located in the "Southern" Region of the province. For this analysis, flows were calculated using the equations for both these regions, and compared to calculations using the provincial regression equation. The results of the analyses are summarized in Table 4.3.

Due to the discrepancy, it was necessary to select a method best suited for the estimation of the peak runoff in the study area. The regional equation for southern basins was the most appropriate method. It gives a high value for the storm peak, although not as high as that obtained from the local basins. The Tantramar River drainage area is larger than the other

Table 4.1 Drainage Areas and Flows for Nearby Basins

River	Drainage Area (km^2)	1 in 20 yr Peak (m^3/s)	1 in 100 yr Peak (m^3/s)
Petitcodiac River	391.0	156.0	221.0
Kelley River	63.2	48.7	68.1
Turtle Creek	129.0	70.4	90.9
Palmers Creek	34.2	25.9	34.2

Note: Flow is peak instantaneous flow.

Table 4.2. Unit Runoff for Nearby Basins

River	Drainage Area (km^2)	1 in 20 yr Peak $(m^3/s)/km^2$	1 in 100 yr Peak $(m^3/s)/km^2$
Petitcodiac River	391.0	0.399	0.565
Kelley River	63.2	0.771	1.078
Turtle Creek	129.0	0.546	0.705
Palmers Creek	34.2	0.757	1.000

Note: Flow is peak instantaneous flow.

Table 4.3. Calculated Storm Flow for the Tantramar River

Equation	1 in 20 yr Peak (m^3/s)	1 in 100 yr Peak (m^3/s)
Southern Equation	199	273
Eastern Equation	150	203
Provincial Equation	138	183
Proration from Local Basins	233	312
Proration from Petitcodiac	132	163

Note: Flow is peak instantaneous flow.

local basins, and it appears that the Southern regression equation accounts for this and gives reasonable results for this analysis. Therefore the selected instantaneous peak runoffs used in this study are:

- 1 in 20 year, 199 m^3/s; and
- 1 in 100 year, 273 m^3/s.

A comparison can be made using the flows which were recorded on the Petitcodiac River during the 1962 flood. The instantaneous peak on the Petitcodiac on April 1, 1962 was 260 m^3/s, which was the highest on record and exceeds by 50 m^3/s the estimated 1 in 100 year flow for the Petitcodiac River. The gauges on the other basins in the area were not established until after 1962. The flow on the Petitcodiac in 1962 indicates that this event was extreme and the same storm event may have produced a runoff approaching the 1 in 100 year flood peak on the Tantramar River.

Although the Tantramar River is the major drainage basin within the study area, it is not a major contributor to the flooding in the Town of Sackville. The local drainage area in the Town itself and the area of Frosty Hollow on Carters Brook appear to be more important. It is the runoff in these area which collects behind existing dykes and aboiteau during high tides and causes flooding in the study area. Estimates of the storm runoff for these areas

have therefore been made. The runoff has been calculated for the Town of Sackville at aboiteau NB37-15 and for Carters Brook at Aboiteau NB37-10 using proration from the smaller local river basins (Kelley River, Turtle Creek and Palmers Creek). These basins will provide a more reliable estimate of the runoff from the smaller drainage basins in the study area due to their similar size. Table 4.4 shows the drainage areas and flows calculated.

Table 4.4 Carters Brook and Sackville Flow

	Drainage Area (km^2)	1 in 20 yr Peak (m^3/s)	1 in 100 yr Peak (m^3/s)
Carters Brook (at Aboiteau NB37-10)	39.6	33.1	44.5
Sackville (at Aboiteau NB37-15)	4.0	5.3	7.1

Note: Flow is peak instantaneous flow.

4.3 Hydraulic Factors

The flooding in the Town of Sackville and the surrounding area is influenced by the control of the runoff from the surrounding land. Prior to the construction of the tidal dam on the Tantramar Marsh in 1960, the flooding was influenced relatively more by tidal levels and the flooding of the Tantramar marshes. After this date, the majority of flooding problems in the area have occurred during the spring period at the time of high runoff. This runoff usually results from a combination of high rains and melting snow.

4.3.1 Aboiteau

There are 18 aboiteau in the dykes within the study area which act to allow water to drain from the marshlands during low tides. Each of the aboiteau along the dykes drains a small local area. They have been sized to accommodate the anticipated runoff from each of these areas. Figure 3.3 shows the locations of the aboiteau within the study area; the characteristics of the individual aboiteau and the areas they drain are summarized in

Table 4.5. The major area of concern for this study is the areas drained by Aboiteau NB37-10 and NB37-15, which carry the runoff from Frosty Hollow and the Town of Sackville, respectively.

TABLE 4.5: ABOITEAU CHARACTERISTICS

Abt No		Length (m)	Height (mm)	Width (mm)	Type	Elevation Inside (m)	Elevation Outside (m)	Area Drained (ha.)	Water Shed (km^2)	Marsh Elevation Lowest (m)	Marsh Elevation Highest (m)	Yr Built	Design Runoff (m^3/s)
RR	1	18.3	1372		Circ.								
	1A	19.8	305		Circ.	3.9	4.1						
	2	18.3	305	305	Box	4.5	4.8						
	3	19.8	152	229	Box								
	4	18.3	762	610	Box								
	5	27.4	1067		Circ.	.3	.5						
NB 24	18	25.6	762	1067	Box	.9	.9	269.5	4.5	5.3	6.1	1951	1.98
	21	20.7	610	914	Box	3.0	3.0	231.1	3.4	5.8	6.2	1953	1.47
	27	17.1	305	305	Box	4.3	4.3	26.9	.3	5.5	6.3	1951	.11
	29	19.5	457	457	Box	3.3	3.4	35.6	.4	5.5	5.9	1953	.17
	31	19.5	610	914	Box	2.3	2.3	45.2	1.3	5.5	6.1	1952	.57
NB 16	2	13.4	457	457	Box	4.5	4.6	6.7	.4	6.1	6.4	1953	.16
	5	19.5	457	457	Box	4.6	4.8	22.1	.3	6.1	6.5	1953	.11
	8	22.6	457	457	Box	4.5	4.6	39.3	.4	6.1	6.8	1953	.18
	12	15.8	457	457	Box	4.2	4.3	46.9	.6	5.7	6.8	1953	.28
NB 5	5	15.2	305	305	Box	3.7	3.6	11.9	.3	5.6	6.4	1950	.11
	8	19.5	610	914	Box	3.2		111.5	2.3	5.6	6.4	1952	1.02
	10	20.1	305	305	Box	4.7	4.6	8.1	.3	5.6	6.4	1950	.11
	12	13.4	305	305	Box	4.2	4.4	31.0	.3	5.6	6.4	1950	.11
NB 37	10	14.3	1067		Circ.(3)	1.0		72.8	39.6	5.5	6.8	1952	7.78
	12	18.3	305	457	Box	3.7	3.6	19.0	1.0	6.0	6.2	1953	.37
	15	13.4	610	914	Box	3.7	3.7	66.8	.6	5.9	6.4	1952	.28

Source: N.B. Department of Agriculture. (Collette, pers. comm.)

Note: Design runoff is flow used for original aboiteau design.

Aboiteau NB37-10, on Carters Brook, was originally constructed with 3910 mm diameter barrels. Since these barrels did not have sufficient capacity to carry the river flow during the 1962 flood, water backed up behind the dyke and flooded Frosty Hollow and the Town of Sackville. In 1965, an 1800 mm square culvert was added to this site. This increased the capacity of the outlet and has helped alleviate the risk of flooding in this area, although the capacity should be reassessed to ensure that it can pass the 1 in 100 year flood peak without excessive water levels occurring upstream of the dyke. The 1 in 100 year peak flow is estimated at 44.5 m^3/s for this area.

It is important that the aboiteau and the approaches to the aboiteau be well maintained. If the capacity is reduced in any way, then the runoff cannot reach the sea during the low tide period. The additional runoff which occurs while the aboiteau are closed is also retained behind the dyke, adding to the water which must be discharged during the next

low tide period. Factors which may cause problems with aboiteau capacity include:

- debris or ice in the aboiteau barrel;
- debris or ice in the approach channel;
- jamming or clogging of the flap gate with debris or ice; and
- undersized aboiteau for the area drained.

It is a possibility that the 1989 flood in Sackville was caused, in part, by problems with Aboiteau NB37-15 which carries the main flow from Sackville (Figure 3.3). The approaches to this 35 year old aboiteau are overgrown and there may be some problems with its operation (G. Smith, Sackville Town Engineer, pers. comm.).

4.3.2 Dams and Control Structures

The Tantramar tidal control dam was completed in 1960 and now provides effective control of the flow on the Tantramar River. The structure consists of 2 gates which are each 5 m wide and 4.8 m high. The dam is operated by the New Brunswick Department of Agriculture. The objective of the operation is to ensure that excessive water levels do not occur on the Tantramar River upstream of the dam. The gates are opened twice each day to allow the water collected during the high tide to drain to the sea.

Regular records are kept of the gate elevations, which have been maintained for the period of January 1988 to September 1989. The records show that the high water levels in the Tantramar River do not exceed 3.5 m and that the usual high water level is an elevation of about 1 m. Figure 4.4 shows the water levels at the Tantramar dam during April 1989 when high runoff was occurring on the Tantramar River. The level in the reservoir reached a peak of 3.5 m on April 1st, which is not high enough to over top the banks of the Tantramar River. Records for the end of February 1989 when the flooding occurred in Sackville, were not available.

Although records were not available for water levels during the 1962 flood at Sackville, flooding problems were not reported for the Tantramar Marsh. There were some reports of

TANTRAMAR RIVER DAM

Reservoir Water Level

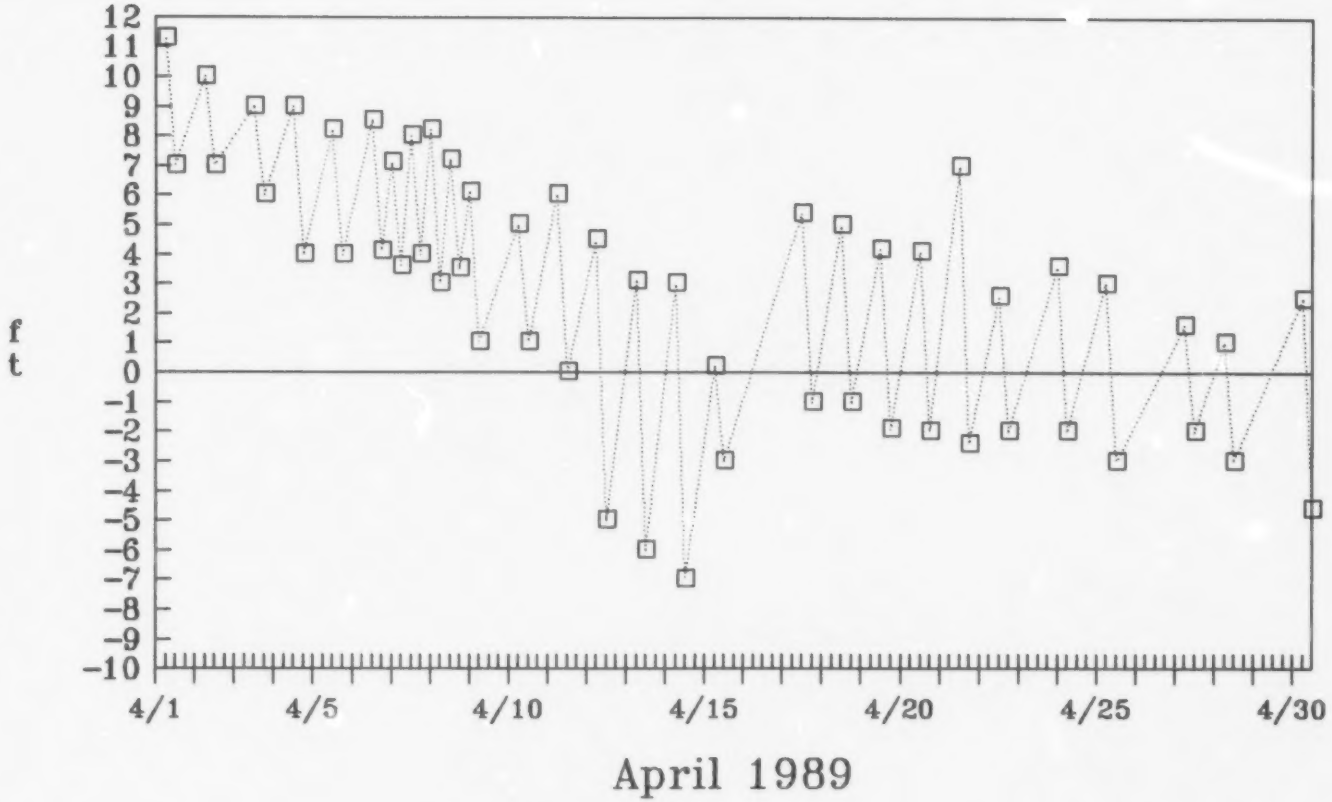

FIGURE 4.4
SOURCE : NB DEPT OF AGRICULTURE (COLLETTE, PERS. COMM.)

minor flooding or rivers flowing at bank full conditions. It appears that the Tantramar dam has fulfilled its objective of alleviating the flooding of the Tantramar Marsh.

4.3.3 Storm Drainage

The Town of Sackville has a relatively small drainage area, comprising about 4 km^2. All of the runoff from the Town is directed through Aboiteau NB37-15. Flow is collected by catchbasins located in the area of Lorne Street and Wellington Street. From there it is directed to an open ditch which passes through a culvert under the railway tracks. The water then passes through open ditches to Aboiteau NB37-15.

The drop in elevation from Wellington Street to Aboiteau 15 is 1.9 m, with an overall slope of about 0.2%. This is a very gentle slope which does not allow for the rapid drainage of water under high flow conditions. In addition, if any of the culverts or ditches are blocked with debris, water is not able to drain easily from the Lorne Street area.

Storm drainage in other areas of the Town may also cause localized backing up of water and flooding. It is important that all runoff be allowed to reach the aboiteau as rapidly as possible so that it may drain during the low tide period.

4.4 Tidal Factors

Sackville is located at the head of the Cumberland Basin on the Bay of Fundy and is subject to some of the highest tidal variation in the world. The normal tidal range at Sackville is approximately 10.8 m, and can reach 15.6 m during a large tide.

The Saxby Gale of 1869 occurred during the peak of the Saros cycle which gives extremely high tides due to the conjunction of the moon and the sun. The period of the Saros cycle is 18 years, 11 days and 8 hours (Desplanque 1982). It was reported that the tidal range during the Saxby Gale was approximately 17.4 m, with a maximum water level of 8.7 m (Dawson 1917). It was accompanied by heavy rain and strong wind which resulted in flooding of extensive areas of the marshlands. The peak water level exceeded the crest of the dykes by nearly 1 metre (Dawson 1917).

The crest of the dykes in the Sackville area average about 8.4 m giving a freeboard of 0.6 m above the large tide elevation. Extreme tides or tides accompanied by storms may overtop the dykes in some areas. This could cause damage to the dykes and may lead to breaching.

5.0 ENVELOPE OF MAXIMUM FLOODING

The envelope of maximum flooding was derived by the evaluation of the water levels at the reference points collected during this study. Due to the variation in the water levels found throughout the study area it was necessary to re-evaluate the points and water levels which were found to arrive at a best estimate of the maximum level of flooding in the study area. The points were plotted on profiles of the study area and on the best available mapping to assist in the evaluation.

The profiles and plotting of the water levels for the area are discussed in the following section. The mapping of the area is included with the supplemental data for this study (WMS 1990), to be used by the Technical Committee for the determination of the flood risk areas for the study area.

During the research and interview phase of the study, information on 14 flood events ,covering a period from 1869 to 1989, was obtained in sufficient detail to allow for the identification of points in the field. Information was also found on flooding which occurs every year in some areas. The initial screening of the data produced a list of 43 reference points representing a total of 58 potential water levels in the study area. The field survey measured the horizontal location of 30 of the reference points. At some of the reference points more than one water level was measured so a total of 37 water level elevations were determined.

Table 5.1 summarizes the elevations established for each of the reference points, and the reliability of each point. Table 5.2 summarizes the ranking of the flood events for which information was found during this study. The greatest amount of information was found for the 1962 flood event. As discussed in Section 4, the 1962 flood occurred during the highest runoff on record in the surrounding area, having a return period estimated in the order of 1 in 100 years. The Saxby Gale in 1869 may have produced higher levels, but insufficient data were collected to allow determination of the maximum water level for the event. The sea level in the area is reported to have risen 0.40 m since 1869 (NSDOAM 1987), so any water levels found for this event would not be representative of present day flood levels.

The majority of the water levels found in the study area were ranked as either Reasonable or Approximate, with only 2 water levels being ranked as Good (Table 5.2). This means that the level found to represent the envelope of maximum flooding found in this study may vary by ± 150 mm.

TABLE 5.1: ELEVATION AND RANKING FOR WATER LEVEL POINTS

Point No.	1869	1912	1933	1953	1958	1962	1963	1967	1978	1989	Annual Pt.	No.
1	7.57 V					7.57 A						1
2						8.18 V				7.24 A		2
3		7.42 V		7.73 V			7.42 V				6.81 V	3
4						7.02 A						4
5						8.02 A						5
6						8.10 V						6
7									V			7
8									V			8
9										6.68 A		9
10										6.70 V		10
11						7.63 R				6.48 G		11
12										6.49 R		12
13						6.82 R						13
14			Y 8.63 V			8.63 R						14
15						8.55 A						15
16						9.41 V						16
17								8.38 R				17
18	6.55 V											18
19						6.70 R						19
20					7.48 A							20
21					V					A		21
22											Y	22
23				V							Y	23
24						5.95 V						24
25			Y			7.47 A						25
26						7.77 R						26
27						7.68 A						27
28											6.86 A	28
29											Y	29
30											V	30
31											V	31
32								V				32
33		V										33
34											V	34
35			Y			13.49 R						35
36						10.27 A						36
37						8.86 R						37
38						7.48 R				6.40 R		38
39						7.93 G						39
40												40
41						9.84 Y						41
42						Y						42
43						6.79 A						43
Total Pts:	2	1	1	1	1	22	1	1	0	6	2	38

Note: Water level elevations in metres.

Label	Description	Range
G	Good	± 25 mm
R	Reasonable	± 50 mm
A	Approximate	± 150 mm
V	Vague	± 300 mm
Y	No Elevation	

TABLE 5.2: SUMMARY OF POINT RANKING

	G	R	A	V	Y	Total
1869	0	0	0	3	0	3
1912	0	0	0	1	2	3
1922	0	0	0	0	1	1
1923	0	0	0	0	1	1
1933	0	0	0	1	1	2
1950	0	0	0	0	1	1
1953	0	0	0	2	0	2
1958	0	0	1	0	0	1
1962	1	9	10	3	1	24
1963	0	0	0	1	0	1
1967	0	1	0	1	0	2
1978	0	0	0	2	0	2
1989	1	2	3	1	0	7
Annual	0	0	1	4	3	8
Total Points	2	12	15	19	10	58

5.1 Flow Profiles

The Sackville area is relatively flat and the problem of flooding appears to be a combination of tidal levels which cause the closure of aboiteau and an under capacity of some of the aboiteau which carry the run-off from large storm events. In reviewing the elevation of some of the points, it was found there was a wide variation of the elevations, making it difficult to determine the maximum envelope of flooding. This variation could be due to a number of factors:

- water levels recorded for the points may not be at the peak of the flood;
- features of the terrain in the study area could cause a variation in the water levels; water could backup behind some features, such as roads or railway embankments; or

- individual recall of water levels may not always be accurate for determining maximum levels.

In order to determine the elevations to be used in plotting maximum historic flood levels, it was necessary to carefully review all points found. Within the study area there are clusters of points which provide estimates of the maximum flood level for different portions of the study area. The major regions represented were:

- Town of Sackville;
- Community of Frosty Hollow;
- Silver (Morice) Lake;
- Carters Brook upstream of Frosty Hollow; and
- The Tantramar and Aulac Marshes.

These areas are discussed individually in the following sections.

5.1.1 Town of Sackville

A total of 11 reference points were found within the Town of Sackville. From these points, 10 elevations for the 1962 flood and 4 elevations for the 1989 flood were obtained. A profile through the Town was plotted to give an indication of the variation of the water levels given by these points (Figure 5.1). Table 5.3 shows the elevations for the points and the variation in elevation due to the assumed ranking.

In reviewing the points, it was found that the variation in the elevations was greater than the range assumed with the point ranking. It was therefore necessary to re-evaluate the reliability of the points before a maximum flood level for the area could be selected.

Figure 5.1 1962 Water Level Points, Sackville

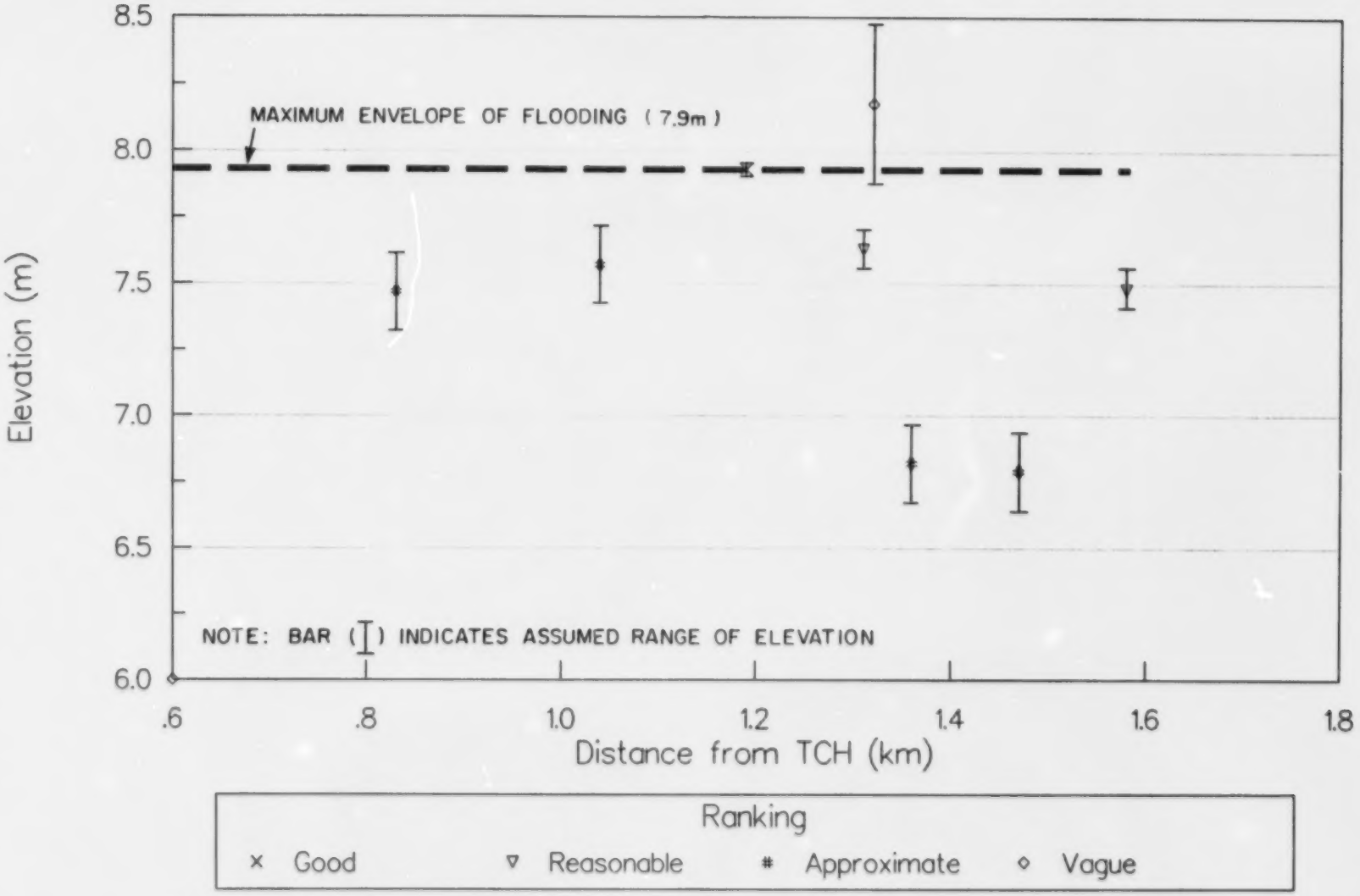

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TABLE 5.3 WATER LEVELS IN THE TOWN OF SACKVILLE

Point	Dist* (km)	1962 Elevations (m) Elev	Rank	1989 Elevations (m) Elev	Rank
24	.35	5.94	V		
25	.83	7.47	A		
1	1.04	7.57	A		
39	1.19	7.93	A		
9	1.29			6.68	A
10	1.30			6.70	V
11	1.31	7.63	R	6.48	G
12	1.31	6.49	R		
2	1.32	8.18	R	7.24	A
13	1.36	6.82	A		
43	1.47	6.79	A		
38	1.58	7.48	R	6.40	R

* Distance from Trans Canada Highway (TCH)

Label	Description	Range
G	Good	±25 mm
R	Reasonable	±50 mm
A	Approximate	±150 mm
V	Vague	±300 mm
Y	No Elevation	

The maximum historic flood level selected for the Town of Sackville was 7.9 m. This level is plotted on Figure 5.1 and it may be seen that it is equal to the highest flood elevation found in the Town and higher than the other water levels found for the 1962 event. The flooding of the Town was found to be due to the collection of water in low lying areas and therefore the level should be consistent throughout the Town. This level is in agreement with Desplanque (1962) who gave a maximum flood level for the Town as 7.8 m.

On the main street of Sackville, one point was found near the Save-Easy store (RP 41). This point was found to have an elevation more than 2 metres higher than any other point in Sackville. The reported level was second hand information (Nicholson 1982) and could not be confirmed, therefore this point has been dropped from this analysis. The level may represent local flooding due to poor storm drainage in the area, but there was insufficient information to confirm this.

Levels reported for the area near the northern end of Sackville (RP 24) were found to be significantly lower than other levels found for the 1962 flood. In reviewing this point, however, it was found that the assumed maximum historic level of 7.6 m would result in the flood contour moving approximately 15 m closer to the houses in the area. It is possible, therefore, that the water level observed at this point was not at the peak of the flood or that the observations were not correct.

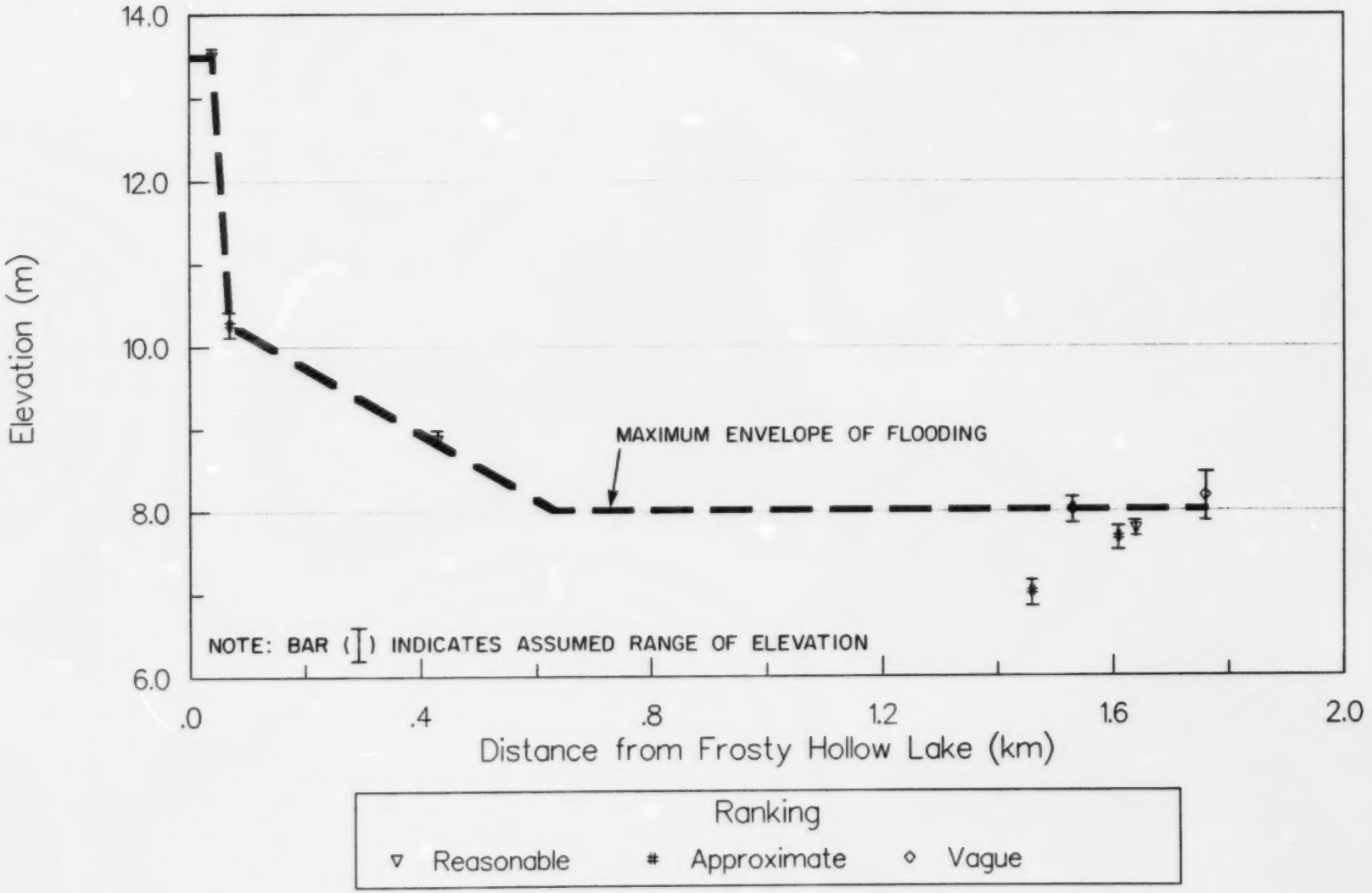
The Sackville area was also affected by flooding in 1989. There were four points found within the Town as a result this event. These show that the maximum level from the 1989 event was approximately 1 m lower than the maximum level reached in 1962.

5.1.2 Community of Frosty Hollow

The community of Frosty Hollow is affected by the runoff from Carters Brook (Frosty Hollow Brook). In this area it appears that runoff which cannot get through the local aboiteau (NB 37-10) collects against the railway embankment and causes flooding in the area. There is sufficient water collected here to cause water to flood along the railway track; this has been identified as a chief problem in the flooding of the Town of Sackville (Wright 1963).

There were six reference points found in this area, five of which gave water levels for the 1962 flood. These levels were plotted on a profile of Carters Brook (Figure 5.2) and show some variation in the maximum water level. The maximum historic level selected for Frosty Hollow was 8.0 m, which is slightly above the level in the Town of Sackville.

Figure 5.2 1962 Water Level Points, Carters Brook



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5.1.3 Carters Brook Upstream of Frosty Hollow

Evidence was found of high water levels on Carters Brook (Frosty Hollow Brook) upstream of the community of Frosty Hollow. Reference points found show that the Brook was flowing over its banks during the 1962 flood. There are culverts and bridges over the Brook which exert some hydraulic control on the Brook and the flood levels found show a slope to the water surface profile. Figure 5.2 shows a profile of the water levels found on Carters Brook from Frosty Hollow to Bulmers Pond (Frosty Hollow Pond). Table 5.4 shows the elevations for the points from the 1962 flood and the variation in elevation due to the ranking assumed.

Bulmers Pond is controlled by a small wooden dam at the outlet. The capacity of the spillway of the dam was nearly exceeded during the 1962 flood; the operator removed all stoplogs but the water level still rose to within 100 mm of the dam crest. The maximum flood level on Carters Brook is assumed to vary from a level of 8.0 m assumed for Frosty Hollow to a maximum of 13.5 m which was reported at the outlet of Bulmers Pond. There were only 2 reference points available to determine this level and there may be some local variation due to the influence of bridges and culverts on the brook. The elevations for the maximum envelope of flooding are presented in Table 5.4.

5.1.4 Silver (Morice) Lake

Silver (Morice) Lake is controlled by a weir at its outlet. In 1962, the capacity of this weir was exceeded by the high runoff in the area. Photographs and movies collected show water flowing around the weir and eroding the river banks. During this flood, several structures on the edge of the lake were inundated. Four reference points were found and a level of 8.7 m was selected as the maximum flood level for the area. No detailed information was obtained on the water level in Morice Creek downstream of the lake, but movie film shows that the creek was flowing over its banks in many places.

TABLE 5.4 WATER LEVELS ON CARTERS BROOK

Point	Dist* (km)	1962 Elevations (m)		Maximum Envelope Elevations (m)
		Elev (m)	Rank	
35	.04	13.49	R	13.48
36	.07	10.27	A	10.27
37	.43	8.86	R	8.82
28	.63			8.02
4	1.46	7.02	A	8.02
6	1.53	8.02	A	8.02
5	1.61	7.68	A	8.02
27	1.64	7.77	R	8.02
26	1.76	8.18	V	8.02

* Distance from Bulmers Pond

Label	Description	Range
G	Good	±25 mm
R	Reasonable	±50 mm
A	Approximate	±150 mm
V	Vague	±300 mm
Y	No Elevation	

5.1.5 Tantramar and Aulac Marshes

The Tantramar Marsh area is largely unoccupied, and the existing structures on the Marsh are mostly barns. It was therefore difficult to obtain any water levels or reference points on the Marsh. There has not been extensive flooding of the Tantramar Marsh since 1960 when the Tantramar Dam and Causeway were completed. Some high water levels have occurred, however these have largely been contained within the banks of the Tantramar River by the operation of the tidal dam.

Prior to the completion of the tidal dam, there was frequent flooding of the marshes. In 1869, water was reported to be in excess of 2 m deep over wide areas of the Marsh (The Borderer, Oct. 7, 1869). In other years the marshes between Sackville and Amherst also flooded extensively.

The points found for the Tantramar Marsh were located well upstream of the Tantramar Dam. These show levels of 6.7 m and have been assumed as the maximum historic levels for the area.

The Aulac Marsh floods regularly due to the under-capacity of the outlet structure on the Aulac River (L. Collette, New Brunswick Department of Agriculture, pers. comm.). In 1962 the water was reported to be flowing over the railway bridge across the River, which is at an elevation of 9 m. This level has been assumed as representative of the maximum historic flood level for the Aulac Marsh area.

5.2 Historic Flood Contours

The maximum historic flood contours were plotted on the best available mapping of the area. These were used to assess the extent of flooding in the study area and to determine the areas which would be affected by the maximum historic flood levels. The Town of Sackville and the Frosty Hollow area have a maximum historic flood limit of 7.9 m and 8.0 m, respectively, which are the levels reached by the 1962 flood event.

Levels were not established for the Tantramar or Aulac Marshes due to a lack of information. Since the construction of the Tantramar Dam, the flooding of that marsh has been largely alleviated. The Aulac Marsh still experiences regular flooding due to limited capacity of the outlet on the Aulac River.

Morice (Silver) Lake experiences high water levels due to the limited capacity of the dam

and spillway at the outlet to the Lake. The maximum historic level of flooding in this area is estimated at 8.7 m, which occurred during the 1962 flood.

Carters Brook, from Bulmers Pond to Frosty Hollow has a drop of nearly 6 m. About 3 m of this occurs at the outlet of Bulmers Pond, and the remainder over the 2 km to Frosty Hollow. Along this section of the Brook, the maximum flood limit varies from 13.5 m to 8.0 m. This limit is approximate, based on limited data and does not account for bridges and culverts which may locally change the flood level.

The maps showing the maximum historic limits of flooding in the study area have been submitted under separate cover to the Technical Committee for this study. These will be used to develop flood risk maps for the study area.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the flood of 1962 is the highest on record. There were also two other significant floods in the area, in 1869 and in 1989. The flood of 1869 may have produced higher water levels than the 1962 flood but there was insufficient data to determine the extent and depth of flooding. The flood in 1989 was localized in the Town of Sackville, and did not result in flooding in other parts of the study area.

There have been a number of changes to the study area over the years which have had an influence on flooding. A tidal control dam on the Tantramar River was completed in 1960 which now controls the flow on that river and has proven effective in preventing widespread flooding of the Tantramar Marshes. In 1965 an additional outlet was added to Aboiteau NB37-10 on Carters Brook. This aboiteau now has an increased capacity and would be more effective in passing the runoff from a flood of the magnitude of the 1962 flood.

The capacity of Aboiteau NB37-10 should be reviewed to ensure that it has the capacity to pass the estimated 1 in 100 year runoff without causing flooding of the Frosty Hollow area. A detailed survey of the existing structure is required to allow proper evaluation of the capacity.

All aboiteau in the study area must be maintained in good working order. Most of the aboiteau are now over 35 years old and are beginning to show signs of age. Reduced capacity due to jamming of flap gates or collapsed barrels could lead to flooding in the area.

If the capacity of Aboiteau NB37-10 is found to be insufficient to pass the 1 in 100 year runoff, the capacity of this aboiteau should be increased. Consideration should also be given to the construction of a cross-dyke between Sackville and Frosty Hollow. This would prevent water from Carters Brook from entering the Town of Sackville from this direction, as occurred during the 1962 flood.

The dykes which protect the area appear to be well maintained and of sufficient height to prevent overtopping under most combinations of wind and tide. These dykes are also showing signs of age, with some section experiencing damage due to winter storms and erosion from wave action. The costs of maintenance are increasing as more extensive repairs are needed to the structures which are reaching the end of their functional life. It may be necessary to upgrade the dykes and other structures in the near future so that they will continue to be effective in preventing flooding of the study area.

It is recommended that the approaches to all aboiteau and storm drainage systems be kept free of debris. The functioning of the aboiteau can be impaired by the presence of debris, and clogging of the approach channels may delay water reaching the aboiteau so that it may be discharged during the low tide period.

There are not enough points to provide the exact extent of flooding in the study area. Water levels are reported generally as heights against structures and not as the maximum extent of inundation. Therefore the water levels selected to define the maximum limit of flooding are based on the assumption that the same maximum water level would apply to all of the study area.

This study found that the maximum historic level of flooding in the Town of Sackville and in Frosty Hollow are elevations 7.9 m and 8.0 m, respectively. It is recommended that these levels be used for the designation of flood risk areas. It must be remembered, however, that this level is dependent on dykes and aboiteau being maintained. Therefore, a return period cannot be assigned to this level of flooding. If the dykes protecting Sackville are breached, the flood level may reach or exceed the maximum historic level.

7.0 REFERENCES

Atmospheric Environment Service (AES), 1988. **Monthly Meteorologic Summaries, Atlantic Region ID: 8870B.** Environment Canada.

Ayer, A., Resident of Frosty Hollow, New Brunswick, Personal communications.

Bulmer, D., (Mrs.) Resident of the lower Fairfield Road area, Sackville, New Brunswick, Personal communications.

Campbell, O., Resident of Sackville, New Brunswick, Personal communications.

Canadian Hydrographic Service (CHS), 1989. **Canadian Tide and Current Tables, Volume 2, Gulf of St. Lawrence.** Fisheries and Oceans, Ottawa, Ontario.

Carter, K., Resident of Sackville, New Brunswick, Personal communications.

Collette, L., New Brunswick Department of Agriculture, Personal communications.

Cormier, A., Manager of Lockharts Beaver Lumber on Lorne St., Sackville, New Brunswick, Personal communications.

Dawson, W.B., 1917. **Tides at the Head of the Bay of Fundy.** Department of Naval Service, Ottawa, Ontario.

Desplanque, C., 1962. **N.B. 37 Sackville Marsh Design Data.** In Nicholson, 1982.

Desplanque, C., 1989. **Storm Tides.** P. 136-149 In: The Tides of the Bay of Fundy. Unpublished MS.

Desplanque, C., 1982. **The Saros and the Saxby Tide.** P. 146-157 In: Nicholson, M. 1982. Historical Flood Review of the Town of Sackville. Prepared for the Federal-Provincial Flood Damage Reduction Program, Environment New Brunswick, Fredericton, N.B. 170 pp.

DMAE and IWD, 1987. **Flood Frequency Analysis, New Brunswick.** New Brunswick Department of Municipal Affairs and Environment and Inland Waters Directorate. Environment Canada, Dartmouth, Nova Scotia.

Environment Canada, 1988. **Consolidated Frequency Analysis 1988 (CFA 88).** Inland Waters Director rate, Hull, Quebec.

Filmore, K., Resident of Sackville, New Brunswick, Personal communications.

Geoplan, 1990. **Flood Documentation and Assessment for the Town of Sackville and Environs.** Supplementary Report to this report. Prepared for the Canada-New Brunswick Flood Damage Reduction Program, Fredericton, N.B.

Inland Waters Directorate (IWD), 1988. **Consolidated Frequency Analysis (CFA88) Users Manual.** Environment Canada, Ottawa, Ontario.

Johnson, B., Resident of Westcock, New Brunswick, Personal communications.

Kindervater, A.D., 1985. **Flooding Events in New Brunswick, An Historical Perspective.** IWD-AR-WPMB-84-65. Water Planning and Management Branch, Inland Waters Directorate, Environment Canada, Atlantic Region, Dartmouth, Nova Scotia.

Nicholson, M., 1982. **Historical Flood Review of the Town of Sackville.** Unpublished report prepared for the Federal-Provincial Flood Damage Reduction Program, Environment New Brunswick, Fredericton, N.B. 170 pp.

Nova Scotia Department of Agriculture and Marketing, 1987. **Maritime Dykelands. The 350 Year Struggle.** Nova Scotia Department of Government Services, Publication Division.

Smith, G., Sackville Town Engineer, Personal communications.

Smith, M., Resident of Sackville, New Brunswick, Personal communiactions.

Snowden, R., Resident of Sackville, New Brunswick, Personal communications.

Spear, D., Marine Environmental Data Service, Ottawa, Ontario, Personal communications.

Snyder, G.G., 1989. Magaguadavic Flood Documentation Study. Proceedings at the 9th Canadian Hydrotechnical Conference. St. John's, Newfoundland.

Tapley, J.H., Resident of Sackville, New Brunswick, Personal communications.

Trenholm, G., Resident of Harper Road, Sackville, New Brunswick, Personal communications.

Turner, H., Resident of Sackville, New Brunswick, Personal communications.

WMS Associates Ltd, 1989. **An Assessment of Flood Damage Potential Along the Magaguadavic River valley from Second Falls to St. George.** Prepared for the Canada - New Brunswick Flood Damage Reduction Program. Fredericton, New Brunswick.

WMS Associates Ltd., 1990. **Supplementary Data: Field Guide.** Flood Documentation and Assessment for the Town of Sackville and Environs. Prepared for the Canada - New Brunswick Flood Damage Reduction Program. Fredericton, New Brunswick.

Wright, J.G., 1963. Letter to New Brunswick Department Agriculture from J.G. Wright, Mayor of Sackville. December 2, 1963. In Nicholson, 1982.

APPENDIX A

DOCUMENTATION AND ASSESSMENT OF FLOODING
TOWN OF SACKVILLE AND ENVIRONS

LOCAL RESIDENTS AND OFFICIALS INTERVIEW GUIDE

Name: _____

Address: _____

_____

Organization: _____

Position: _____

Telephone: _____

Interview guide # _____

1. What years do you remember flooding in the Sackville Area?

_____ _____ _____

Fill in **Flood Event Information Form** for each year.

2. Do you have any records or recollections that might provide information on past floods, such as:
   - the height of water
   - location of ice jams
   - photographs and films of flooded areas
   - locations of high water marks
   - damages

No _____ Go to Q.3

Yes _____ Fill in **Flood Event Information Form** for each event and/or piece of information.

3. Can you think of any other individuals or organizations that may have that type of information or evidence?

No _____ Yes_____ Could you please provide names, locations and telephone numbers so that we may contact these individuals?

(a) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(b) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(c) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(d) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

(e) Name: _____ Tel: _____

Location and Comments: _____

_____

_____

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DOCUMENTATION AND ASSESSMENT OF FLOODING

TOWN OF SACKVILLE AND ENVIRONS

FLOOD EVENT INFORMATION FORM

Interview guide # _____

A. Date event started: _____

Time: _____ Don't Know ( )

B. Date event peaked: _____

Time: _____ Don't Know ( )

C. Duration of flood: _____

D. Describe location and extent of flood waters. (Provide sketch or locate on map.)

_____

_____

_____

E. How high was the flood? (Describe and photograph, or give level if known):

_____

_____

_____

F. Do you know the type of flood?
Describe appropriate flood type.

(a) Ice Run ( )
Ice Jam ( )

Do you know where the ice run/jam was located? (Cross out one)

No ( ) Go to G.
Yes ( ) Please describe the location and height of run/jam (if known). (Provide sketch or locate on map.)

_____

_____

_____

(b) Open Water ( )

_____

_____

(c) Tidal ( )

_____

_____

(d) Don't know ( )

G. What damages did the flood cause to specific structures and what was the cost of damages?

None ( )
Don't know ( )

_____

_____

H. Are you aware of any remaining scars, physical marks or evidence of flooding (e.g. on buildings, trees, other structures) that show the level the water reached?

No ( ) Go to I.
Yes ( )

(i) Please describe the location and the type of mark as accurately as possible so that our surveyors may locate it. (Take photograph and provide sketch and/or location on map)

Description and location of Marks

_____

_____

_____

_____

_____

I. Do you have any photographs, films or videos that show this flood event (or the marks you mentioned)?

No ( )

Yes ( )_____Photograph ( ) Video ( )
Film ( ) Other ( )

Can we have access to a copy of these?

Print provided ( )
Negatives provided ( )
Lent for duration of study ( )
Can ask for it when doing actual surveying? ( )

Photo taken of mark ( )
Photo taken of photo ( )

APPENDIX B

LIST OF PEOPLE INTERVIEWED
SACKVILLE AND ENVIRONS

Hazel Allen
Herman (Hum) Amos
Charles Anderson
Glenara Anderson
Frederick Anderson
Allison Ayer
Margaret Barnes
Donna Beale
Evelyn Bembridge
Joan Bembridge
Mr. Burnett
Otis Campbell
William Campbell
Joyce Carter
Kieth Carter
Susan Clough
Laurie Collette
Alain Cormier
Laura Cormier
Brian Doncaster
Cheryl Ennals
A. J. Erskine
Gerard Estabrooks
Herman Estabrooks
Lloyd Estabrooks
Ola Estabrooks
Margaret Fancy
Charles George
Pat George
Floyd Hicks
Ron Ibbitson
Don Jeffery,
(Pridham's Studio Ltd)
Ben Johnson
Alfred Lynch
D. M. Maxwell
Jim McGill
David McKay
Mrs. Donald Palmer
Bill Phinney
Helen Sears
Patty Sears
Al Smith
Gordon Smith
Helen Smith
Mitchell Smith
Roy Snowdon
Walter Snowdon
Catherine Tapley
John H. Tapley
Mariville Thompson
Cortney Tower
Geraldine Trenholm
Harold Turner
Bea Ward
Mrs. Lewis Wells
Helen Wheaton